LCA on Danish fish products and application of system expansion in the fishery

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IFL Project Report
28 - 03

Rannsóknastofnun fiskiðnaðarins

DECEMBER 2003

LIFE CYCLE ASSESSMENT OF SEAFOOD 3rd WORKSHOP

Eva Yngvadóttir

Skýrsluágrip Rannsóknastofnunar fiskiðnaðarins

Icelandic Fisheries Laboratories Report Summary

Titill / Title	**Life Cycle Assessment of seafood, 3rd workshop**		
Höfundar / Authors	*Eva Yngvadóttir*		
Skýrsla Rf /IFL report	28-03	*Útgáfudagur / Date:*	December 2003
Verknr. / project no.	1513		
Styrktaraðilar / funding:	*NARP (Nordic Arctic Research Programme)*		
Ágrip á íslensku:	Þessi skýrsla greinir frá niðurstöðum þriðja vinnufundar í samnorrænu verkefni um vistferilgreiningu sjávarafurða, sem haldinn var í Þrándheimi, Noregi 10. nóvember 2003. Umræðuefnin á fundinum tengdust m.a. notkun aðferðarfræði vistferilgreiningar í iðnaði, áhrif veiðarfæra á vistkerfið, s.s sjávarbotninn, og tengingu vistferilgreiningar við rekjanleika. Þátttakendur voru vísindamenn á Norðurlöndum sem nýta vistferilgreiningu á einn eða annan hátt í starfi sínu eða námi. Fundurinn var styrkur af Nordic Arctic Research Programme		
Lykilorð á íslensku:	*LCA, fiskur, umhverfisáhrif, áhrif veiðarfæra*		
Summary in English:	This report contains the outcome of the 3rd workshop in a Nordic project on LCA of seafood. The workshop was held in Trondheim Norway, 10. November 2003. At the workshop, presentations on the use of LCA, biological effects in LCA, effects on the ecosystem and combining LCA to traceability were presented and discussed The participants were scientists from the Nordic countries and other interested persons who use LCA in their work, as well as invited guests. The workshop was funded by NARP (Nordic Arctic Research Programme)		
English keywords:	*LCA, fish, environment, usability, ecosystem effects*		

TABLE OF CONTENT:

1. INTRODUCTION

This report describes the 3rd and last workshop held in the project "Work forum: Life cycle assessment for seafood," funded by NARP. It contains overheads and brief summaries of the presentations and the results of the discussions that took place at the workshop.

The objective of this project is to establish a work forum for scientists working on LCA in fisheries and the fish processing industry and is primarily dedicated to the development of the LCA methodology for seafood. The first workshop was held in Gothenburg in 2001, the second in Iceland in 2002 and the third was held in Trondheim, Norway in November 2003. The participants in the last workshop used the opportunity to discuss further cooperation in this field.

2. WORK PROGRAMME AND PARTICIPANTS

Workshop programme 11. November 2003

8:45	Welcome /practical information *Eva Yngvadóttir,IFL*
9:00	Biological effects in LCA, *Ottar Mikkelsen, NTNU*
9:30	Practical experiences in use of LCA towards the industry, *Annik Magerholm Fet, NTNU*
10:00	Coffee
10:15	LCA on Danish fish products and application of system expansion in the fishery, *Mikkel Thrane, Aalborg University*
10:45	Environmental effects of cod, salmon and chicken, *Harald Ellingsen, SINTEF Fisheries and Aquaculture*
11:15	Discussion
12:00	Lunch
13:00	Fishing activity and ecosystem effects, *Irene Huse, Institute of Marine Research*
13:30	Combining LCA with trace ability, *Erling Larsen, DFU*
14:00	Topics to discuss, all participants • How to communicate the LCA results to the industry • Is there a way to make a simple LCA tool that can be used by SME´s • How to assess the direct effects on the ecosystem because of fishing, e.g. impact on seafloor, fish stocks etc.
15:30	Coffee
16:00	**Closing of the workshop**

16:30 -18:00 Forming applications for new network and research projects

1. Network on environmental indicators, application to NMR
2. A research project

19:00 Dinner

11. November 2003

8:30-12 Writing an application (group work)

Participants:

Friedrike Ziegler *fz @sik.se*	SIK	Sweden
Harald Ellingsen *Harald.Ellingsen@sintef.no*	SINTEF	Norway
Mikkel Thrane *thrane@plan.auc.dk*	Ålborgs University	Denmark
Halla Jónsdóttir *halla@iti.is*	Ice Tech	Iceland
Eva Yngvadóttir *eva@rf.is*	IFL	Iceland

Invited speakers:

Ottar Michelsen *ottar.michelsen@iot.ntnu.no*	NTNU	Norway
Annik Magerholm Fet *Annik.Fet@iot.ntnu.no*	NTNU	Norway
Irene Huse *irene.huse@imr.no*	Inst. of Marine Research	Norway
Erling Larsen *epl@dfu.min.dk*	DFU	Denmark

Other Participants:

Almudena Hospido SIK Sweden
ahospido@usc.es

Erwin Meissner Schau SINTEF Norway
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3. PRESENTATIONS

Appendix 1 contains overheads and brief summaries from the presentations presented at this workshop.

4. SUMMARY OF DISCUSSIONS

Before the participants arrived they were asked to consider some questions for the workshop. They were:

- How to communicate the LCA results?
- Is there a way to make a simple LCA tool that can be used by SME´s?
- How to assess the direct effects caused by fishing on the ecosystem, e.g. the impact on the seafloor, fish stocks etc.?

A brief summary from the discussions follows:

4.1 How to communicate the LCA results?

There were intense discussions about the possible use of the LCA results. It is clear that they are useful for legislators, producers and consumers but the question is how it is best to introduce them to these groups. LCA is a complicated method that can be difficult to communicate. The tendency is to make LCA studies that are more complex and thus more difficult to communicate.

4.2 Is there a way to make a simple LCA tool that can be used by SME´s?

The LCA methodology is very complicated. Apparently, only very big companies, such as Unilever and Norsk Hydro are currently using this method to assess their performance regarding environmental effects. The industry knows that it needs to consider the life cycle of their products but the methodology today is too complicated. Today, this kind of study needs to be done in cooperation with research institutes. One way to simplify this method could be to develop subsystems where the industry could select a system that suites their line of production.

4.3 How to assess the direct effects of fishing on the ecosystem, e.g. the impact on the seafloor, fish stocks etc.

Currently, there are several evaluation methods available that emphasise on different environmental objectives. The evaluation methods used today in software tools like Sima Pro, LCAit and GaBi focus on process industries like paper, polymer etc. Fish is a biological raw material and there is no evaluation method available today which fully takes into account the effects on the seafloor, fish stocks, by-catch and discard etc. By using system expansions some of this effects can be taken into consideration to a certain degree. It is possible to use quantitative or qualitative LCA to point out hot spots in, e.g fisheries, that is which function has the most environmental effect, like oil consumption, land use, fish resources, by-catch and discard etc.

5. APPENDIX

ABSTRACTS FROM PRESENTATIONS

5.1 Biological effects in LCA

Ottar Michelsen
Department of Industrial Economics and Technology Management
Norwegian University of Science and Technology

'Biodiversity loss' is not an appropriate impact category in LCA since biodiversity is affected through a range of impacts, i.e. pollutants, climate change and changes in land use. Different impact categories in LCA should be as exclusive as possible. Here focus is on biological changes as a result of resource use and land use. These should be treated as separate impact categories in LCA.

For most species exploited as resources, extraction of humans is the dominant cause of endangerment. Extraction of biotic resources should be treated as a separate impact category in LCA where the impact is the sum of extraction rates multiplied with a species dependent characterisation factor. This characterisation factor must reflect the population status. Also species captured or harmed accidentally must be included in this category, i.e. bycatch in fisheries.

Use of area is normally separated in use and transformation of area. In both cases the challenge is to find suitable measures for area quality. Different measures are proposed, i.e. species diversity and NPP, but there exists no consensus on how to do this.

Here a new approach is proposed based on ecosystem scarcity, ecosystem vulnerability and conditions for maintained biodiversity. This is based on the assumption that it is the maintenance of ecosystem functions that is important, not the number of species as such.

The scarcity and vulnerability of an ecosystem give a measure on quality based on the assumption that rare ecosystems are the most valuable since they are most likely to be extinct. The changes in quality are measured according to what degree conditions for maintained biodiversity are present after changes in use of the area. Instead of using direct measures on biodiversity which in most cases are complicated and time-consuming to achieve, this could be done using ecosystem specific indirect indicators on biodiversity.

Biological effects in LCA

Ottar Michelsen
Dep. of Industrial Economics and Technology Management

NARP Workshop, Trondheim - November 10th 2003

Impact assessment of resources and land use

- Normally regarded as three separate input-oriented environmental interventions in LCA:
  - Extraction of abiotic resources
  - Extraction of biotic resources
  - Allocation of land areas to man-controlled processes
- A call for more focus on these issues in LCA-studies, but in most cases these are omitted, partly as a consequence of immature methodology

Extraction of biotic resources

- Only a tiny fraction of the existing species are used as resources
- Mainly fish for food, trees for wood and plants for medicines
- For most of these, extraction by humans are the dominant cause of endangerment

NTNU

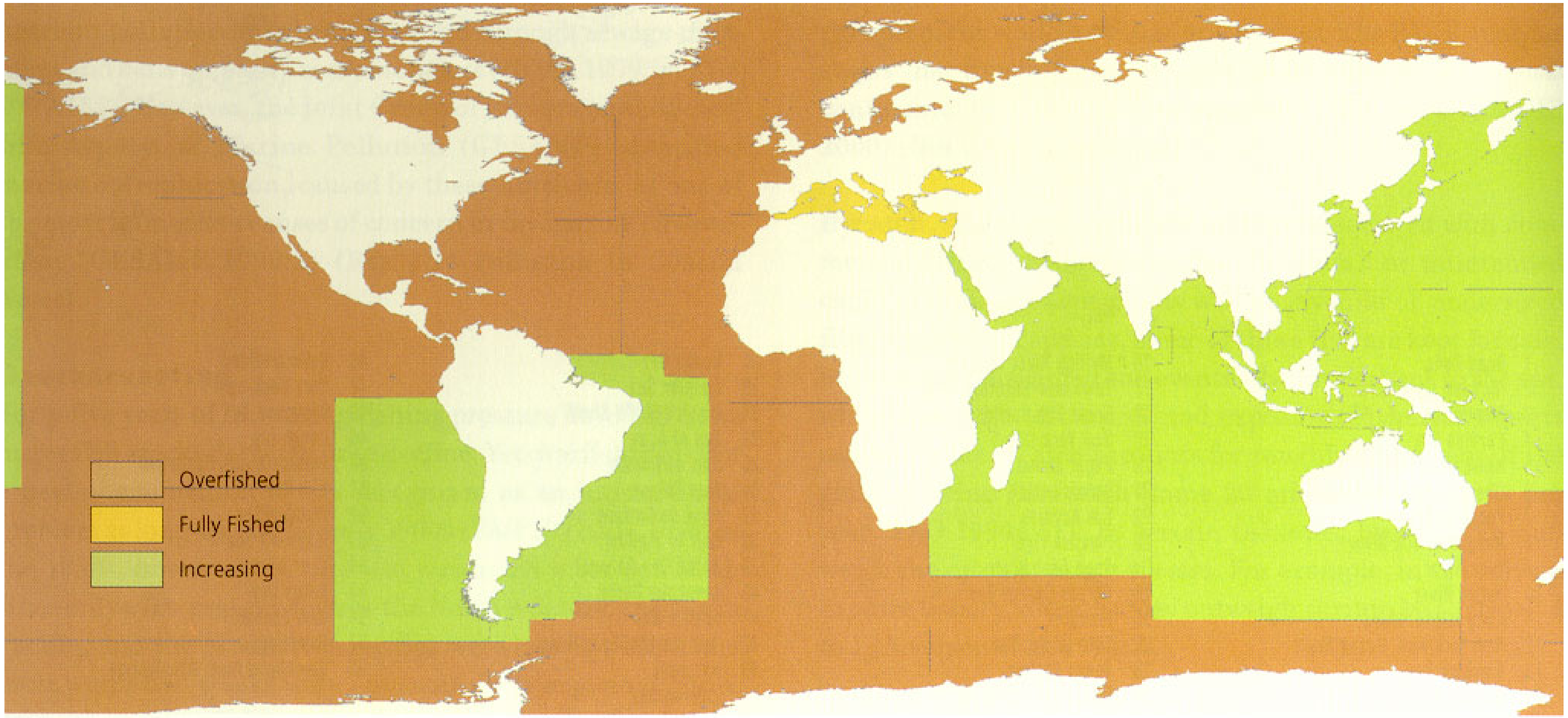
Extraction of biotic resources in LCA

- $$impact = \sum_{i=1}^{n} A_i \times Q_i$$
- A_i – data of environmental intervention (i.e. fish catch)
- Q_i – characterisation factor
- According to SETAC one of the main reasons to include this impact category is to allow "*comparison between fishing methods with broad bycatch and low bycatch*"
- All bycatch must hence be included, also fish that is brought back to the ocean but dies due to the treatment (i.e. some small individuals that is not brought on board due to mechanical arrangements)

Two ways of characterising

- Extraction of biotic resources influence two different areas of protection (AoP)
  - Availability of the resource (if population declines due to extraction)
  - Impact on biodiversity and ecosystem functioning (if changes in population size influence other organisms and ecosystem processes)
- Characterising can hence be resource oriented or ecosystem function oriented

Overexploitation is a problem…

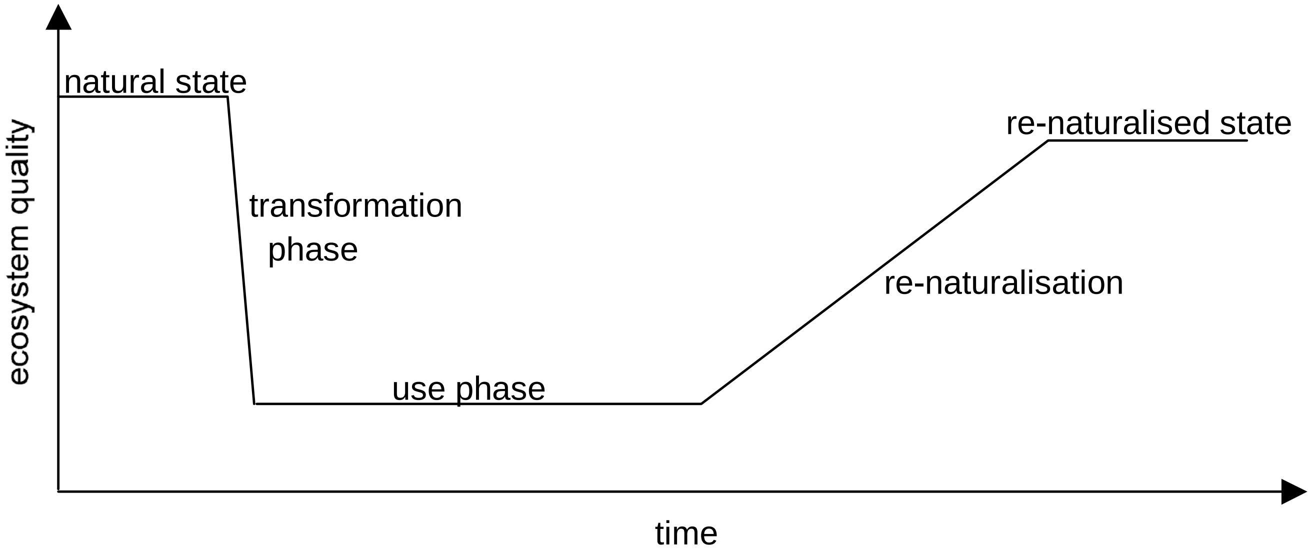


ource: Burke et al. [PAGE] 2000. The map is based on Grainger and Garcia (1996); analysis is based on landings data collected between 1950 and 1994 for he top 200 species-/fishing-area combinations, which represent 77 percent of the world's marine production, as explained in the technical notes for Data able 4 in Coastal, Marine, and Inland Waters. Table is based on FAO (1999c, 1999d).

Use of land (or water!) area

- Normally separates between
  - Use of area — area $A \times$ time $t \times$ quality
  - Transformation of area — area $A \times$ quality difference
- There is however no consensus about how to measure quality – some solve this by simply avoiding the quality measure and regards land use as a product of space and time

Quantification of land use/transformation



What is the quality of an area?

- Different valuation criteria are proposed:
  - Different measures of “Life-support-functions”
    - i.e. NPP
  - Species diversity
    - i.e. number of species or number of red listed species
  - Rarity of nature type

- Primarily used for land areas, not marine areas

Some assertions about quality measures

- Maintenance of LSF are dependent on conserved ecosystem functions
- Ecosystems with few species are as valuable as ecosystems with more species
- It is important to maintain the total biodiversity
- The nature types that are rare (naturally or due to changes caused by human impact) are most important to protect

NTNU

Suggestion for quality measurement

- Area quality : ES * EV
- Quality change : (ES * EV * CMB) – (ES * EV)
- ES – Ecosystem Scarcity
  - Natural occurrence of nature type
- EV – Ecosystem vulnerability
  - How much of the nature type is still present
- CMB – Conditions for Maintained Biodiversity
  - To what degree is biodiversity maintained within the area during the impact
- ES, EV, CMB have all values between 0 and 1

Conditions for maintained biodiversity

- Fish farming
  - Impact on behaviour of wild animals/fish
  - Genetic pollution
  - Aesthetic impact
  - Emissions
    - antibiotics
    - fodder spill
    - copper
    - etc.
- Fishing
  - Impact on seabed

Conclusions

- Biodiversity aspects are undoubtedly important when evaluating environmental performance from fishery and fish farming
- But
  - The methodology to include this aspects in LCA are immature
  - The problems in valuating area value and area impact in marine areas are even more underdeveloped than for land surface
- "What's get measured gets managed"
  - Most measurements are better than no measurements

Where to start?

- Two measures could be included more or less immediately
  - Extraction of fish stocks
    - Different species should be weighted according to population status
  - Area use
    - If it is not possible to agree on a method to valuate the different areas, area should be included as such

5.2 Practical experiences in use of LCA towards the industry,

Annik Magerholm Fet, NTNU
Norwegian University of Science and Technology
Department of Industrial Economics and Technology Management

Information about the environmental performance of transport systems is believed to become increasingly important in the future. Waterborne transport has traditionally been considered the best alternative from an environmental point of view. However, in recent years more attention has been put on the way environmental performance is documented. The presentation shows how the environmental performance of different transport chains can be compared against each other by a set of environmental impact categories. By the use of different weighting models, slight variations in performance are observed. The presentation is based upon the results from the Norwegian project “Environmental Performance of Transportation - A Comparative Study”, a co-operation between the Norwegian University of Science and Technology (NTNU), Det Norske Veritas (DNV) and Ålesund College, and from the pre-project “Life cycle Evaluation of ship transportation - Development of methodology and testing”, which demonstrated that Life Cycle Assessment (LCA) is an appropriate method to identify and evaluate environmental impacts during the life cycle of a ship. However, it concludes that to evaluate the environmental performance of different transport chains, both methodological development, improvement of relevant databases and evaluation aspects must be addressed in further research. The presentation shows suggested models and guidelines for the documentation and comparison of environmental performance of different transport chains in a life cycle perspective. In the work a common set of principles for describing the transport chain, the systems and their subsystems is used. In addition a simplification of the method of evaluating the environmental performance of transport chains is shown for a set of environmental impact categories for the transport sector. It also gives a few recommendations on how to allocate infrastructure activities to the environmental burden of the transport chain.

Practical experiences in use of LCA towards the industry

Annik Magerholm Fet
Professor in Environmental Management
Department of industrial economics and technology management
NTNU

LCA-workshop Sintef 10.November 2003

Challenges

- Moving people and freight in an environmentally sustainable manner will be one of the biggest challenges of the 21st century
- The overall objectives of the OECD's Guidelines for Environmentally Sustainable Transport (EST) are to provide
  - an understanding of EST,
  - its implications and requirements, and
  - to develop methods and guidelines towards its realisation

Environmental management tools:

- **Process assistance tools**; e.g. input-output analyses for production process.
- **Product assistance tools,** e.g. life cycle assessment along the entire value chain of a product
- **Management assistance tools**, e.g. an environmental management system that ensures continual improvements

International environmental management standars

ISO14001, 4 Environmental Management System (EMS).

ISO14010-12 Environmental Auditing (EA) (now ISO 19011).

ISO14020-25 Environmental Product Declaration (EPD).

ISO14031   Environmental Performance Evaluation (EPE).

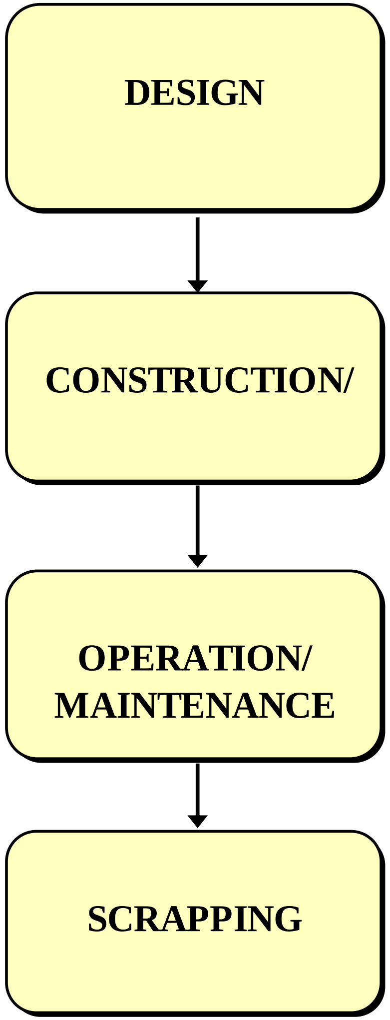
ISO14040-48 Life Cycle Assessment (LCA).

ISO 14050 Vocabulary

ISO 14062 Environmental aspects in product standards

The life cycle of a vessel

The life cycle is introduced by its four main phases – design, construction, operation and maintenance, scrapping



Sources to impact





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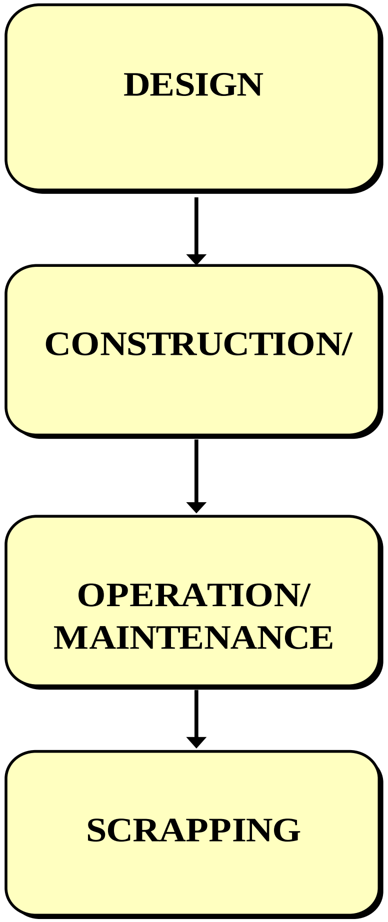
Environmental aspects



<u>Construction and maintenance, shipyards activities</u>

- Release to water of grinding and blasting substances, anti-fouling and other coatings.
- Release to air of noise, dust, particles, gases from e.g. welding and aerosols, smells.
- Production and disposal of waste: metal waste, oil-contaminated waste, paint, cables, etc.

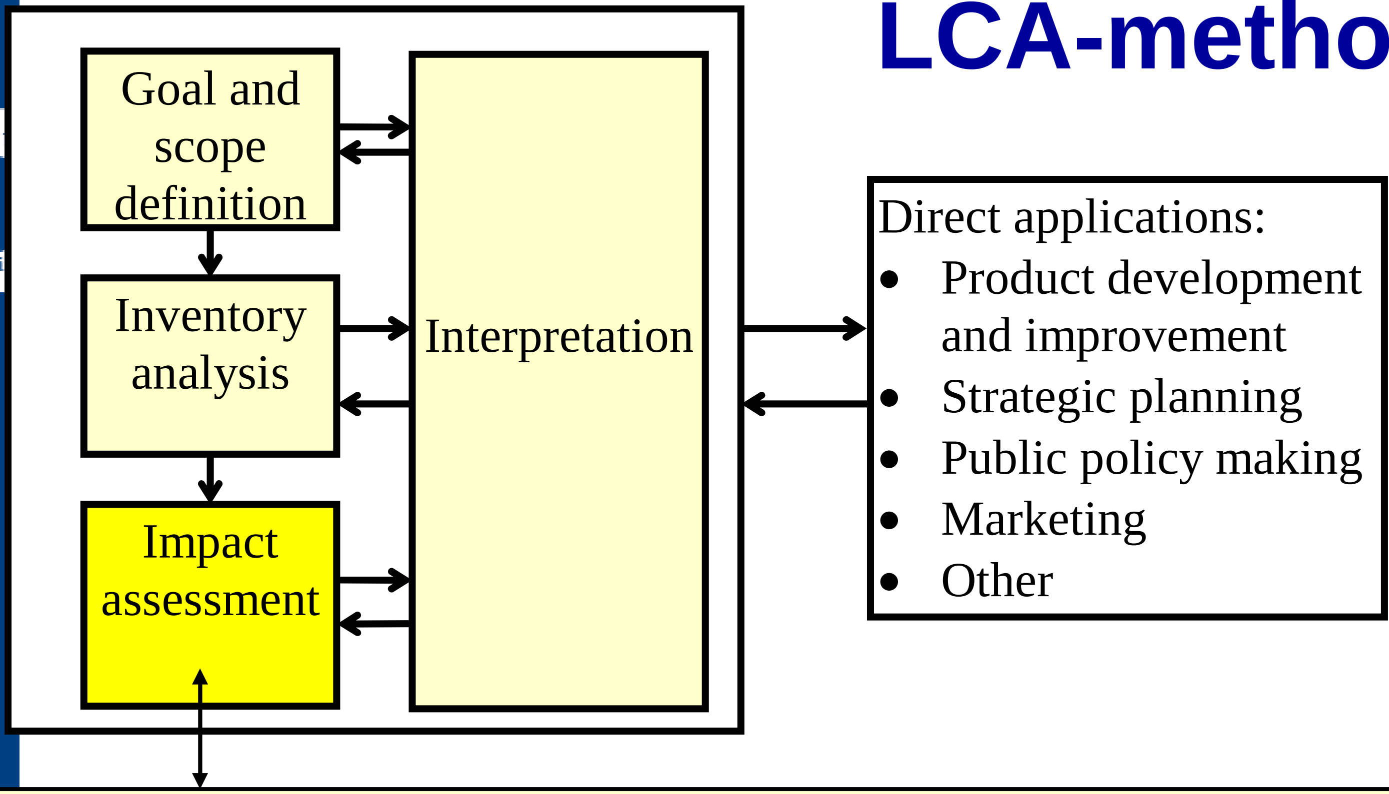
<u>Operation</u>

- Emissions of CO2, CO, NOx, SOx, HC
- Ballast water, oil spills, etc
- Oily waste, tank residues

<u>Scrapping</u>

- metal bearing wastes (Cadmium, lead, mercury)
- Oily waste, waste containing PCB and other hazardous materials, mix of chemicals etc.

LCA-methodology

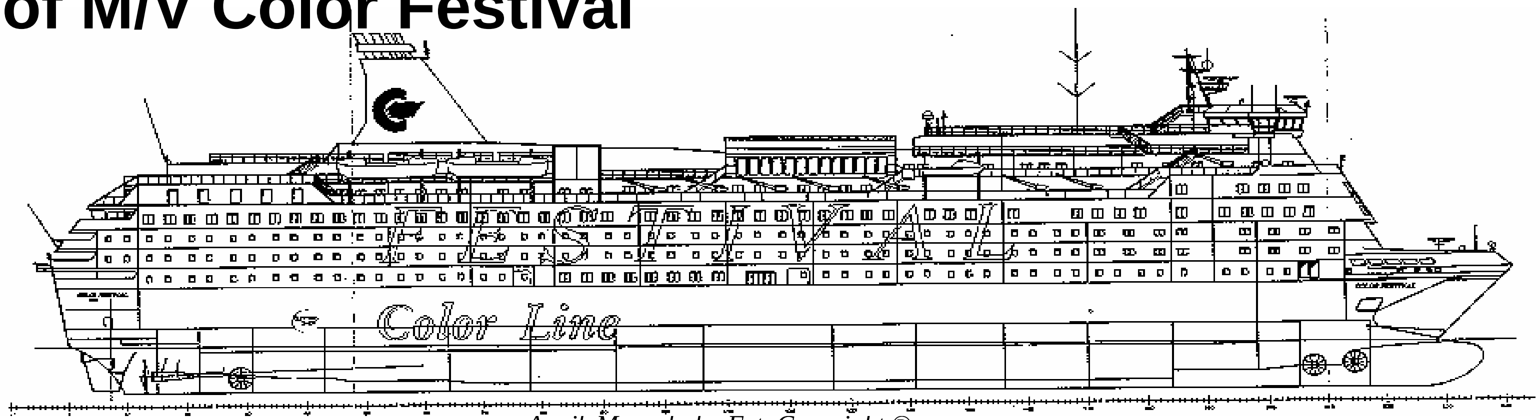


- **Classification:** the parameters from the inventory are noted under the relevant impact categories.
- **Characterization:** the relative contributions of inputs and outputs are assessed to their assigned impact categories.
- **Valuation:** the relative importance of different environmental impacts are weighted against each other.

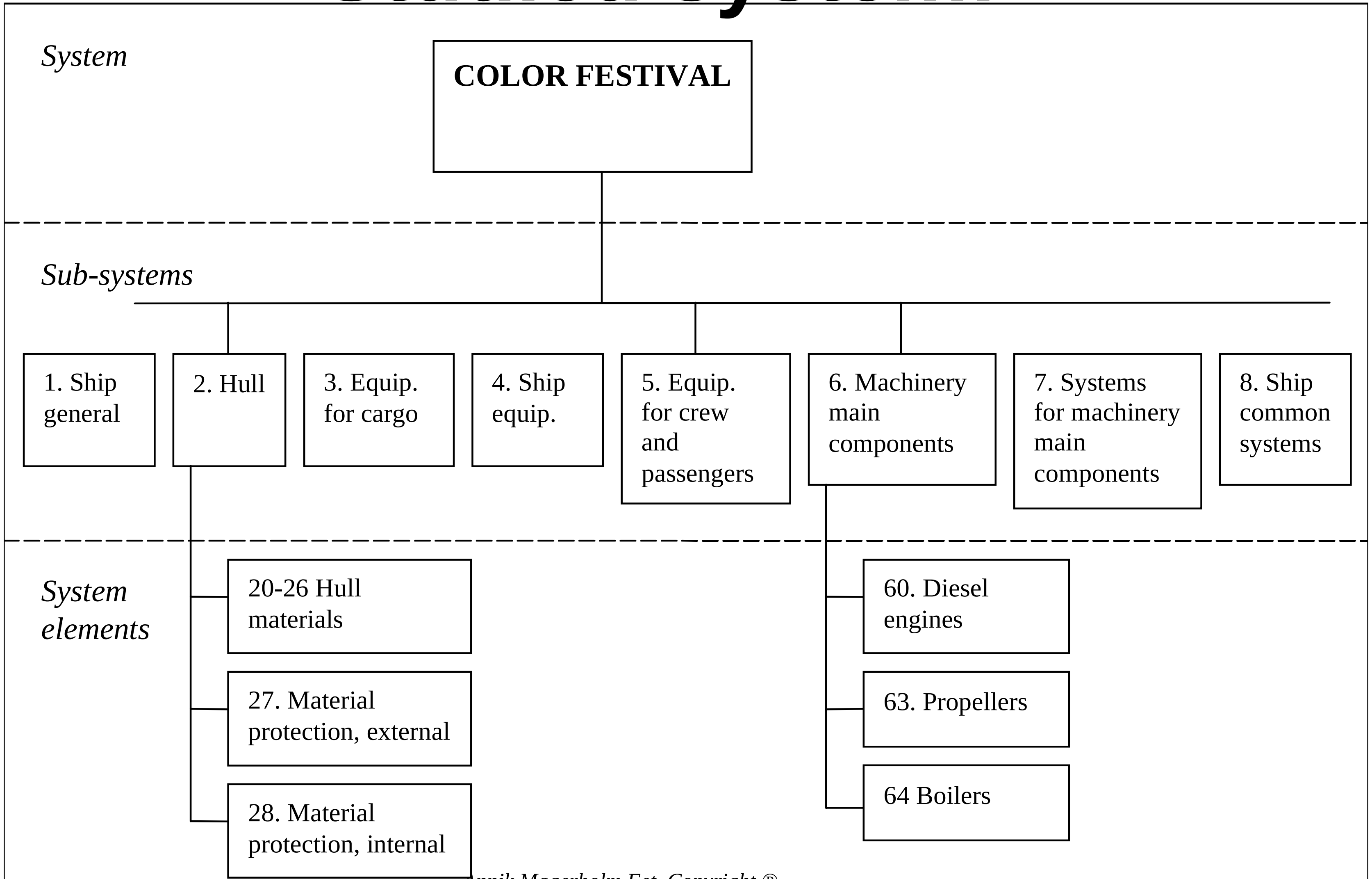
Case 1: ”Life Cycle Evaluation of ship transportation - Development of methodology and testing”

Goal: To demonstrate that the LCA-method is applicable for environmental life cycle evaluation for ship transportation.

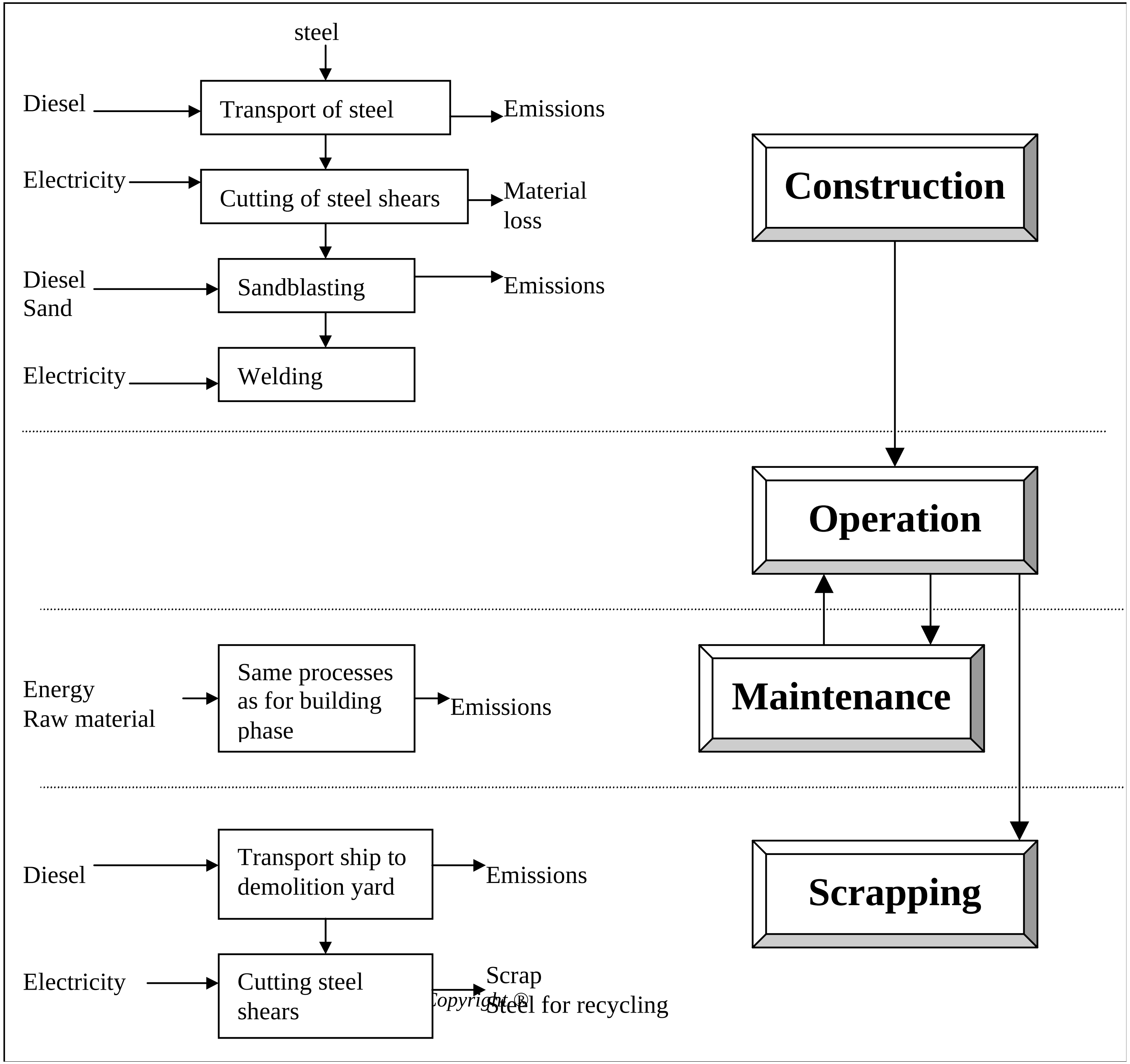
Case study: Screening Life Cycle Assessment of M/V Color Festival



Studied system:



Flow chart Hull materials



Data collecting principles:

Data (cradle to gate data) are partly found from logs, in databases, in literature, by interviews, in research reports or by estimates.

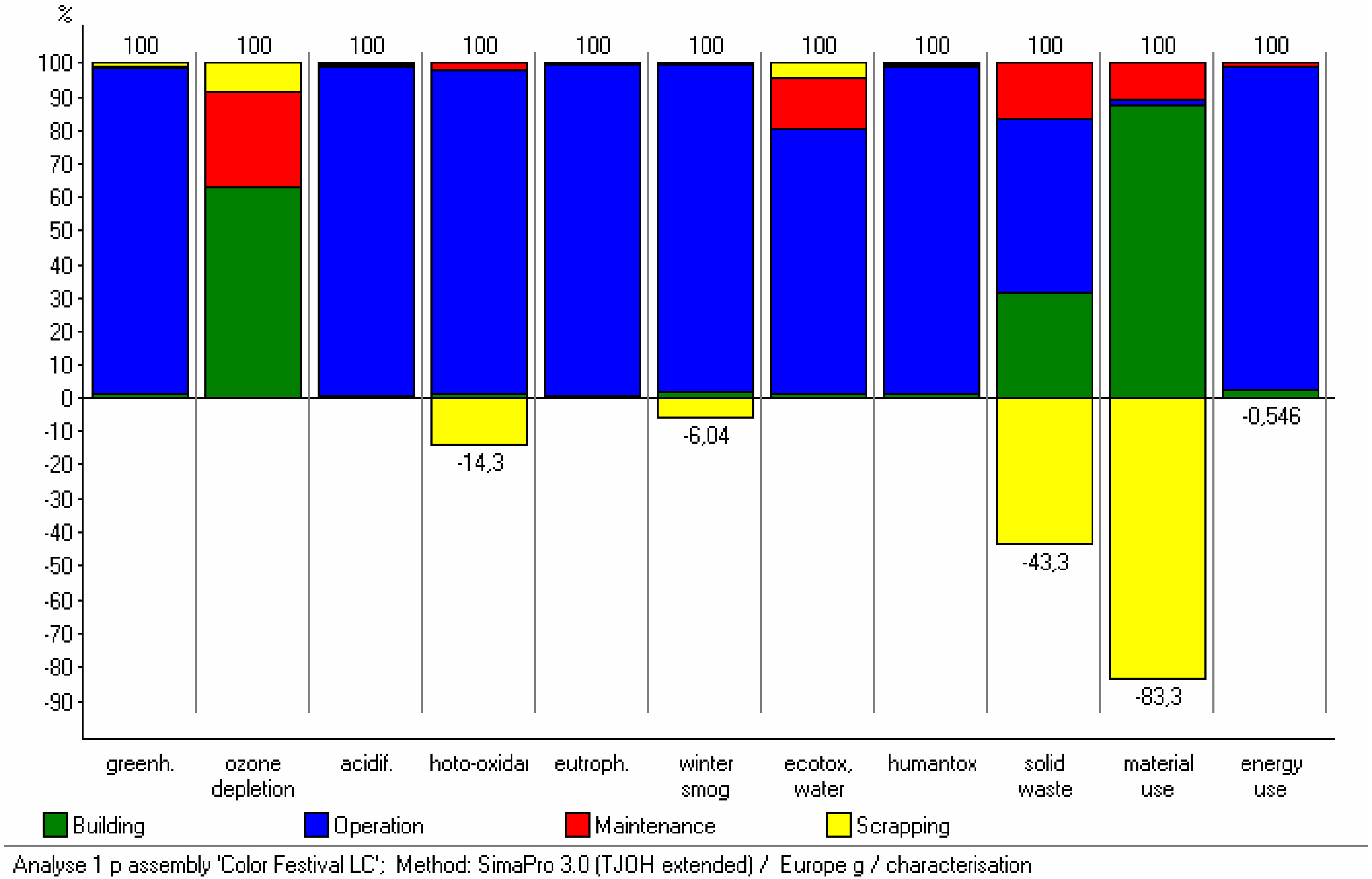
It is assumed that the traffic figures and the emissions are the same throughout the entire lifecycle, and 95% of all steel is recycled after ended life time.

Environmental impact categories:

The impact categories for this evaluation are:

- greenhouse effect,
- ozone depletion,
- acidification,
- photo oxidant formation,
- eutrophication,
- winter smog formation,
- ecotoxicity to water,
- human toxicity,
- solid waster,
- material and energy use.

The ships life cycle phases' contribution to the environmental impact categories



Conclusions from this LCA-project:

- LCA can be applied to analyse the environmental aspect related to a ship, but it is very time consuming and methodological simplification is needed.
- It is necessary to involve construction and maintenance yards, together with the ship-owner to get easy access to reliable information.
- Existing valuation techniques used within LCA should be used very critically.
- The functional unit is important when systems are to be compared against each other.
- It is beneficial to break the system down into sub-systems.
- The results are often uncertain because of bad data quality and inconsistency in the system boundaries

Conclusions, cont.:

Most important environmental aspects are:

- fuel combustion and leakage from antifouling during the operation of the ship,
- cleaning and recoating during maintenance,
- non-recyclable materials and local pollution in the scrapping phase.

The main issues to be addressed in further research:

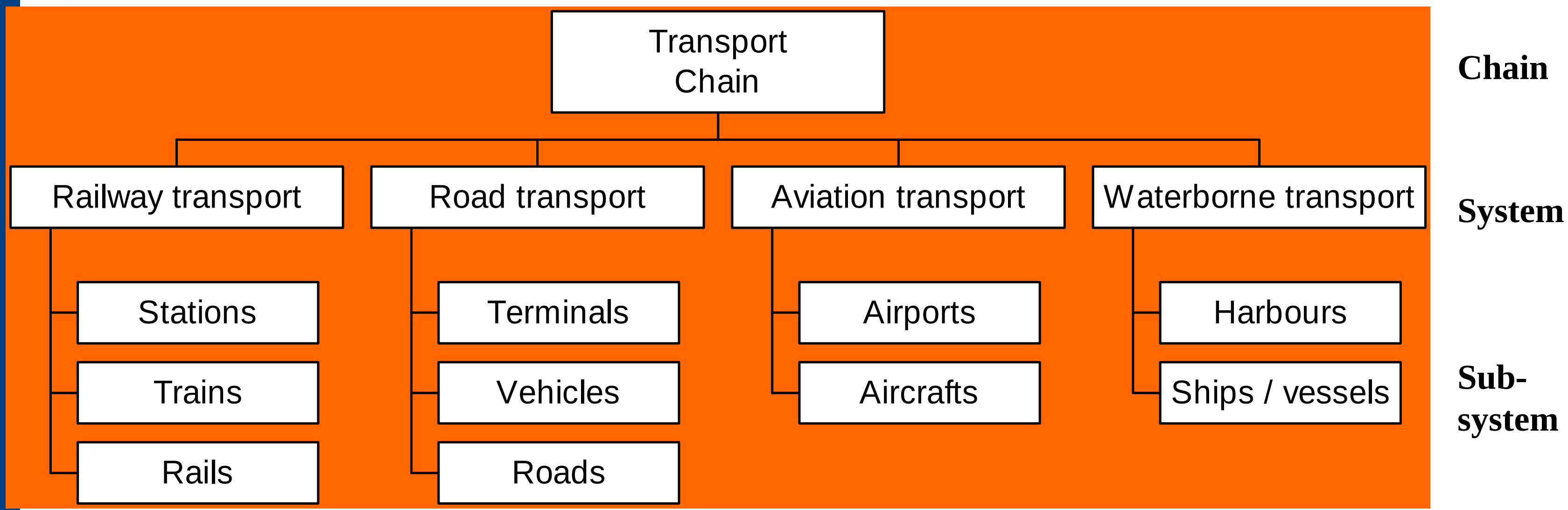
- methodological development,
- improvement of relevant databases, and
- analytical tools for evaluating the environmental aspects of transport systems.

Transport project: Environmental performance of transportation.

Challenges: To compare different transport systems requires:

- a common set of principles for describing the transport chain, the systems and their subsystems,
- a set of guiding principles on how to set the system boundaries and how to allocate infrastructure activities to the environmental burden of the chain,
- a simplification of the method of evaluating the environmental performance of transport chains, and
- a common set of environmental impact categories for the transport sector.

Transport chain



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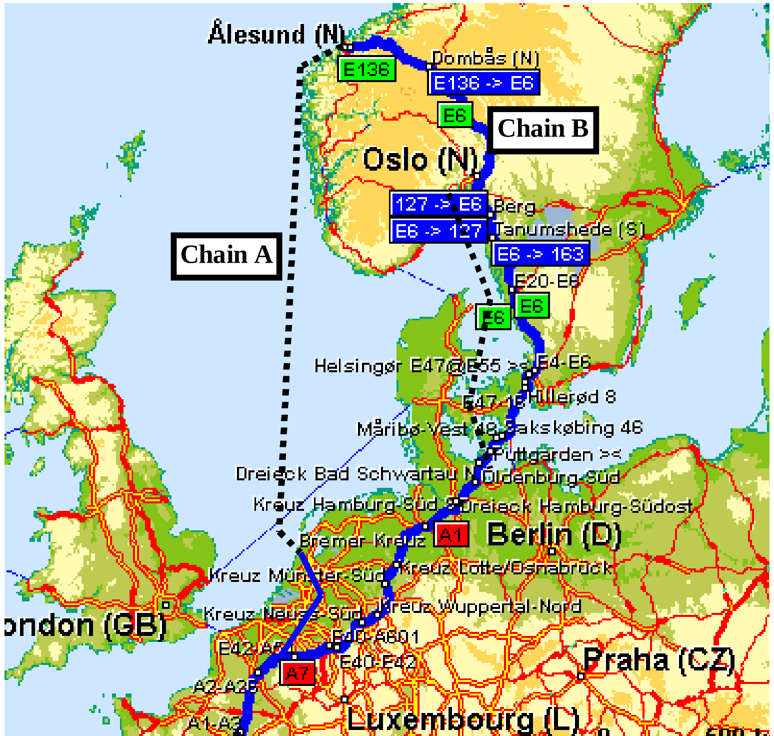
Case 3: Transport of frozen fish

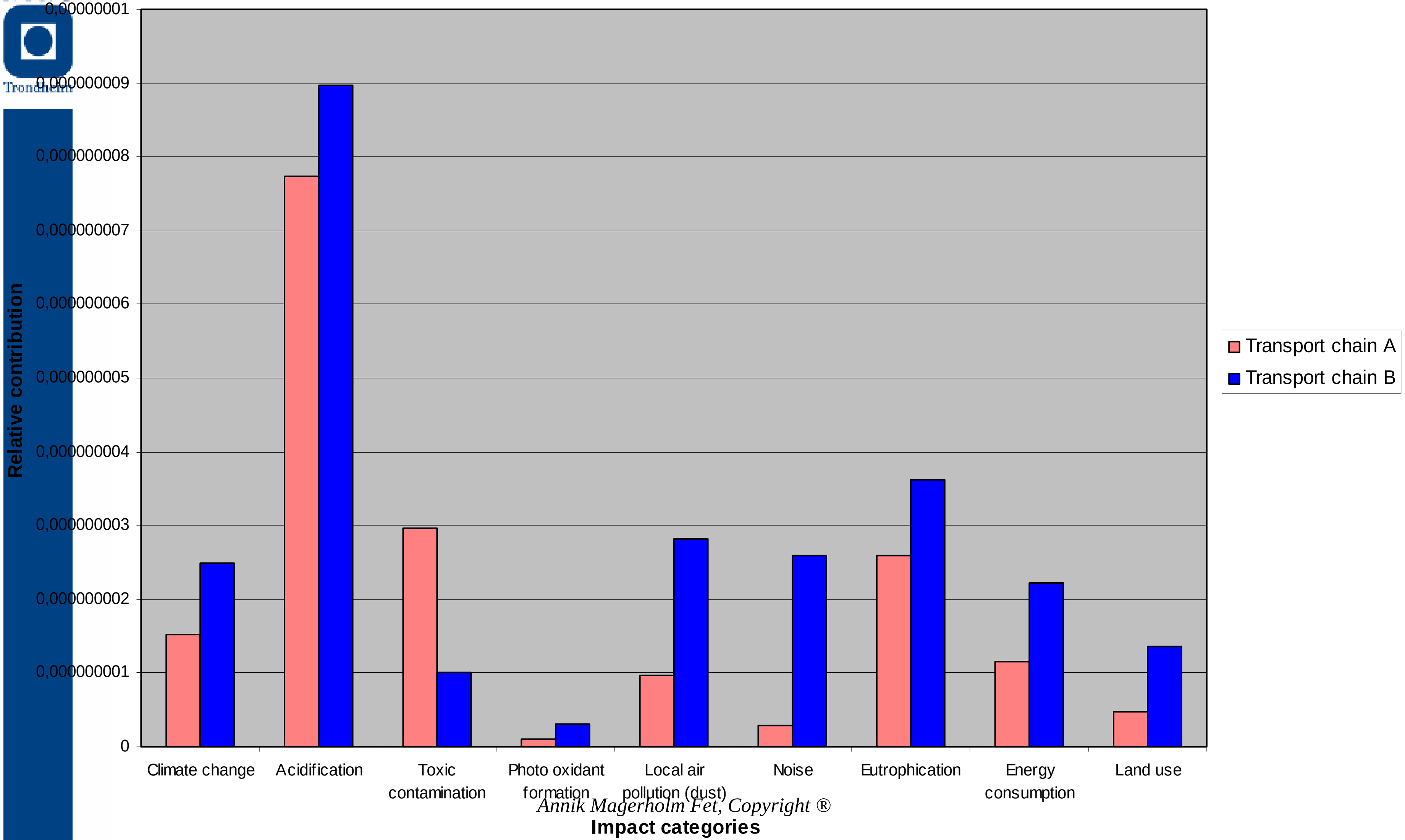


- Chain B
  - Road transport
    - Termo Trailer HFR/Norfrig
    - Road Ålesund - Oslo, Kiel - Paris
  - Waterborne transport
    - Harbours in Oslo and Kiel
    - M/V Kronprins Harald (or M/V Prinsesse Ragnhild)
- Chain A
  - Road transport
    - Terminal in Ijmuiden
    - Termo Trailer HFR/Norfrig
    - Road Ijmuiden - Paris
  - Waterborne transport
    - Harbours in Ålesund, Måløy and Ijmuiden
    - RoRo-ship M/V Nordjarl

Inventory results (per ton fish)

Impact category	Compound	Chain A	Chain B	Charact.	Contr.	Normalisat.
Climate change	CO_2	84 kg	138 kg	1		
	N_2O	0,24 g	0,71 g	320		
	CH_4	1,5 g	4,4 g	25	EP(j)	55 598 000 000
Acidification	SO_2	938 g	867 g	1,00		
	NO_X	1286 g	1802 g	0,70		
	NH_3	0,022 g	0,064 g	1,88	EP(j)	237 448 000
Toxic contam.	Pb (to air)	(no data)	(no data)	160		
	TBT	0,10 g	0,034	250		
	Cu			2	EP(j)	8 453 000
Local air pollut.	particles	24 g	70 g	1		344 700 000
Photo oxid. form.	NMVOC	36,6 g	106 g	1		24 800 000
Noise	Area >55dBA	10,4 m^2	94 m^2	1		36 146 088 884
Eutrophication	NH_3	0,022 g	0,064 g	3,64		
	NO_X	1286 g	1802 g	1,35	EP(j)	671 081 500
Energy consump.	MJ	930 MJ	1812 MJ	1		813 PJ
Land use	Area (m^2)	0,23 m^2	0,66 m^2	1		485 719 000

Normalised inventory results, case 3

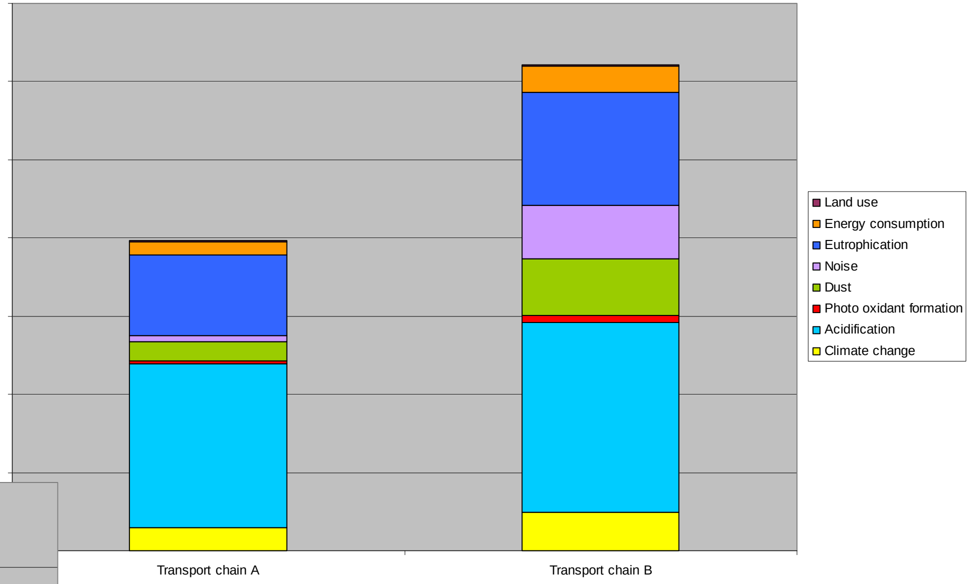


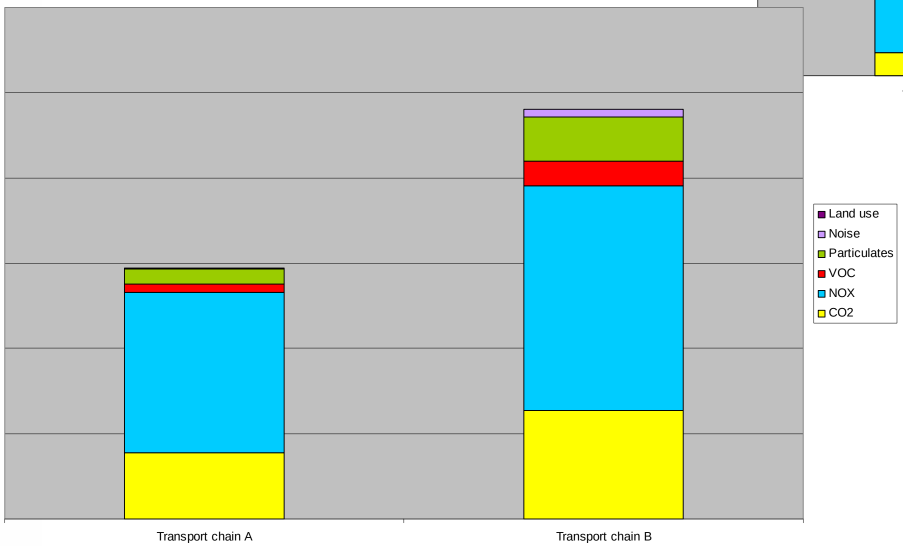
Valuation

- The Eco-indicator 99
- EPS
- The ExternE Methodology
- Valuation according to political goals
- Valuation according to panel procedures
- Valuation according to the recommendations in the OECD project on Environmentally Sustainable Transport (EST)

Weighted results, case 3:

According to political goals





According to the EST-project

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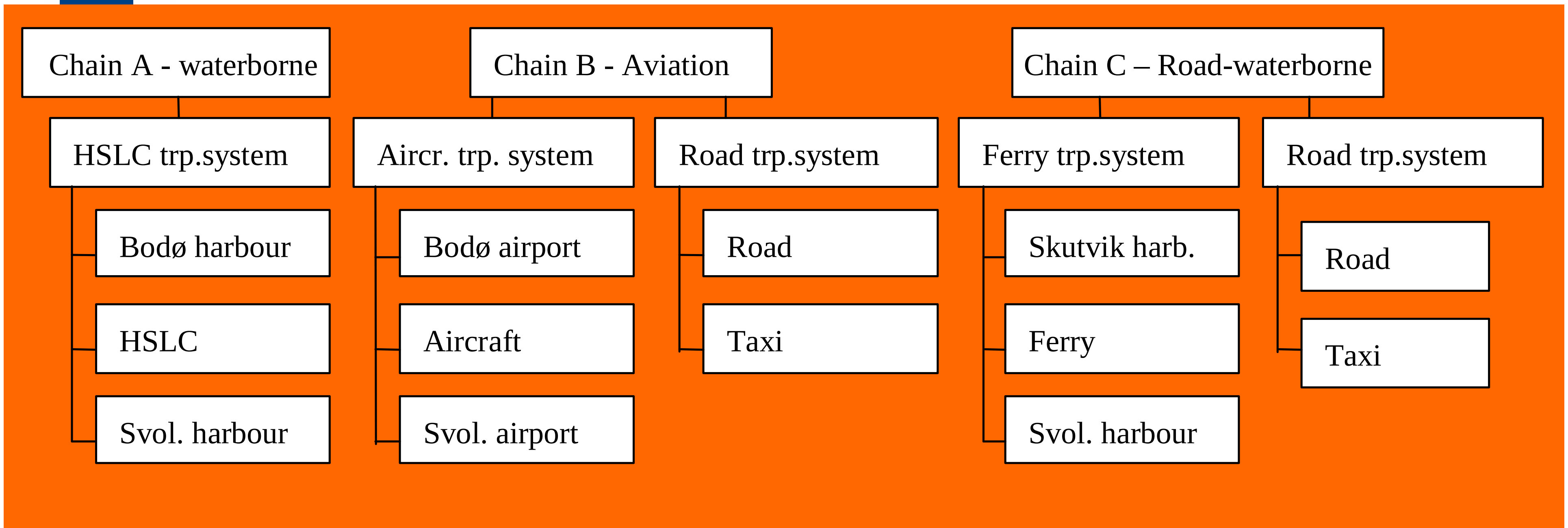
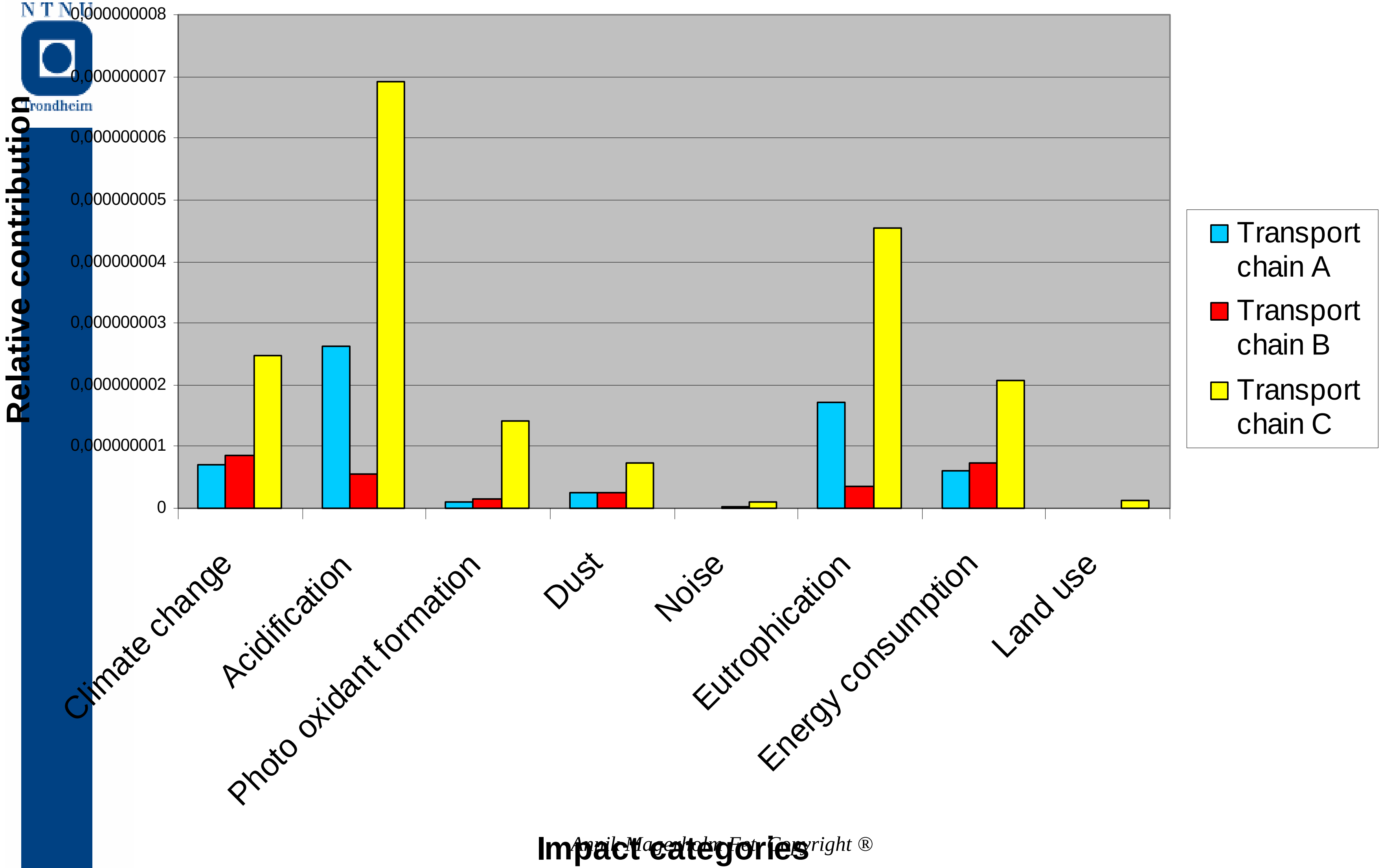
Case study: Passenger transport



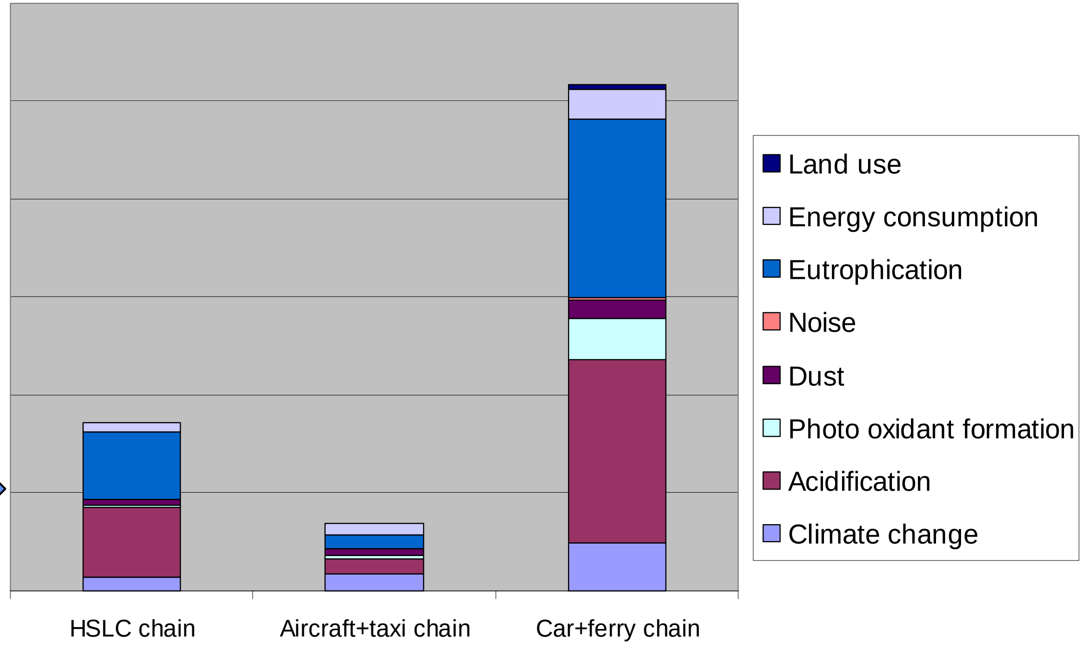
Impact cat.	Compound	Chain A	Chain B	Chain C	Charact. (EF(*j*) $_i$)	Contributi. ($Q_i \bullet EF(j)_i$)	Normalisa.
Climate change	CO_2 (kg)	38,6	47,3	133	1		
	N_2O (g)	0,973	3,15	10,2	320		
	CH_4 (g)	2,8	2,07	27,7	25	EP(j)	55 598 000 000
Acidification	SO_2 (g)	26,8	5,92	65,6	1,00		
	NO_X (g)	854	181	2256	0,70	EP(j)	237 448 000
Local air pollut.	particles (g)	6,08	5,97	18,4	1		344 700 000
Photo -oxidant form.	NMVOC (g)	33,5	50,5	490	1		24 800 000
Noise >55dB	Area–time (m^2h)	184	4462	29067	1		36 146 088 884
Eutrophicat.	NH_3 (g)	-	-	-	3,64		
	NO_X (g)	854	181	2256	1,35	EP(j)	671 081 500
Energy (fuel) cons.	MJ	488	600	1680	1		813 PJ
Land use	Area (m^2)	0,004	0,005	0,064	1		485 719 000
Exploited capac.	(%)	47,5	37,6	20			

Normalised results

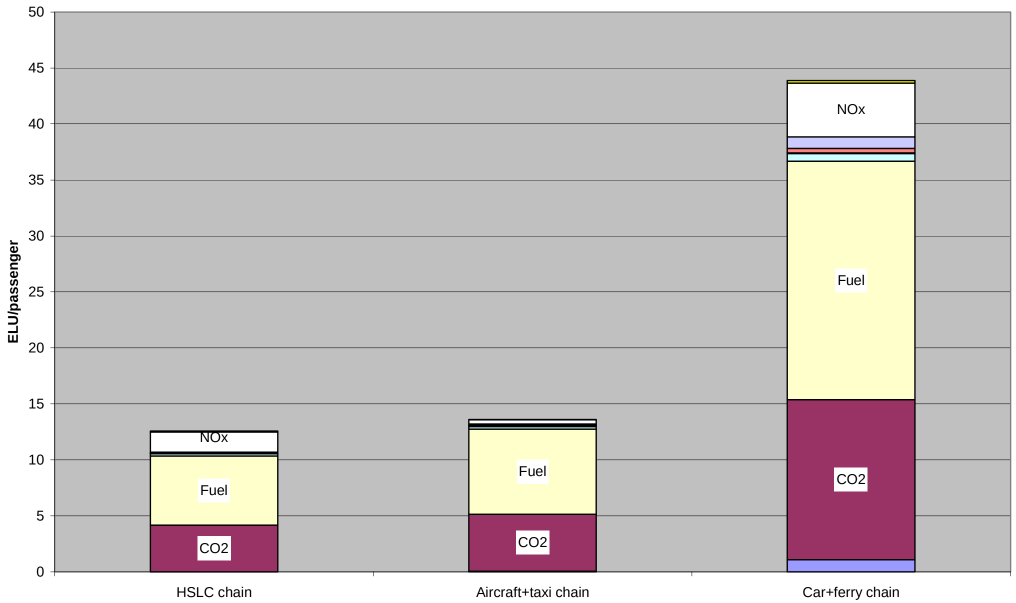


Interpretation

According to political goals/priorities

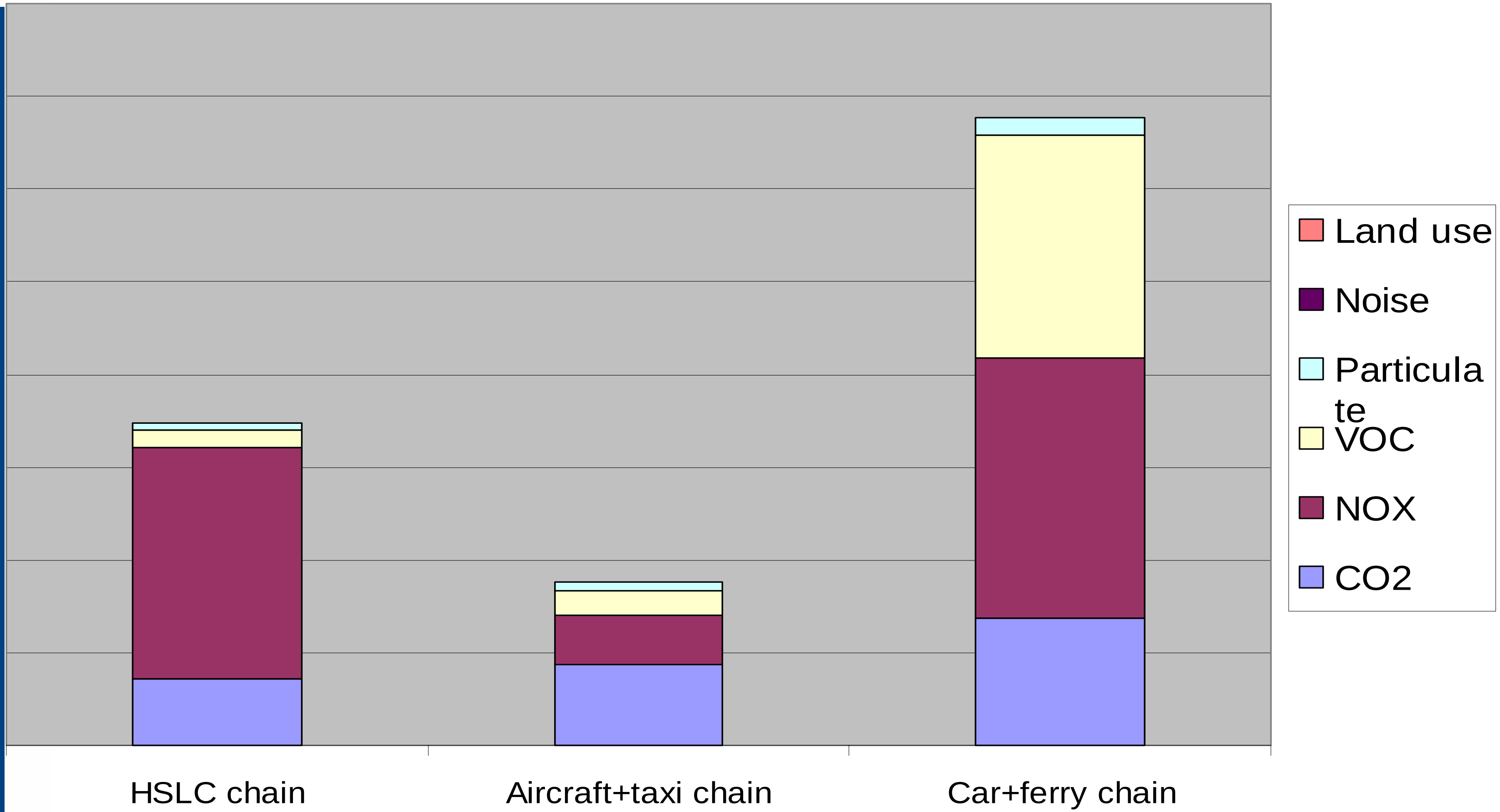


According to the EPS-method



Annik Magerholm Fet, Copyright ®

Interpretation according to recommendations in the EST-project



Performance indicators and environmental reporting

The recommended indicators by OECDs EST project are

- **land use, noise, particles, VOC, NOx and CO2.**

To calculate the EST-indicators and the GRI-indicators by means of the formulas presented in the paper, the needed input parameters for the calculations are:

- **F = fuel consumption**
- **D = distance**
- **e = emission factors**
- **P = engine power**
- **C = exploited capacity**

Discussions and conclusions

- The models show how to compare the environmental performance of transport chains, but not how to optimise each chain
- The study is limited to the operational phase of the transport systems, building and maintenance contribute most to local environmental impacts
- The impact category toxic contamination (TBT, Pb, defrosting fluid etc.) is difficult to evaluate since local impacts are not included in some of the evaluation models.
- Evaluation shows that land-use contributes minimal to the total environmental burden
- Evaluation of noise exposure shows that noise should not be neglected as an important impact

Further work:

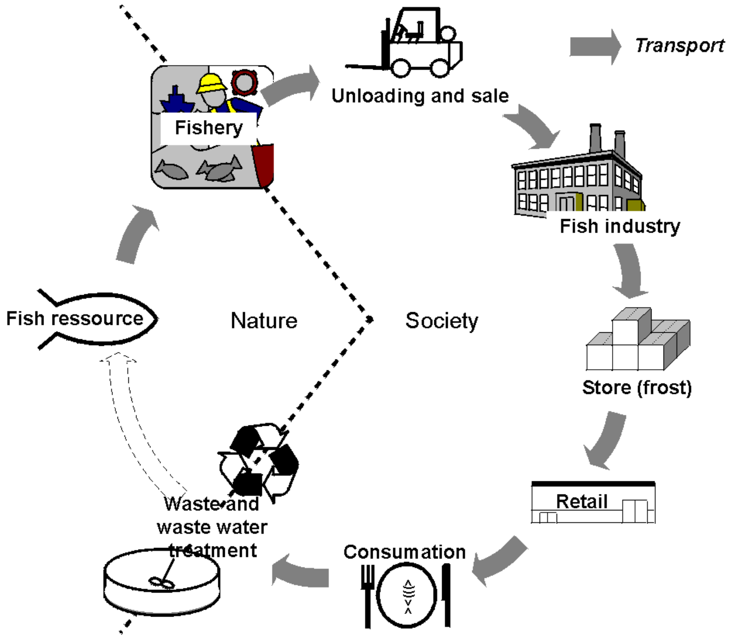
- It seems that a simple weighting method e.g. by using the six indicators recommended in the OECD EST is sufficient (CO_2,, NO_X , VOCs, particulates, noise and land-use)
- Further research should focus on how to use these principles to evaluate and optimise alternative transport chains and standardise models of calculating the eco-efficiency of transport chains.

5.3 LCA on Danish fish products and application of system expansion in the fishery.

Mikkel Thrane
Aalborg University
Denmark

I have used a change-oriented approach in my LCA studies. Thus, I have focused on the environmental consequences of a change such as a slightly increase or decrease in the production volume or the exchanges related to the fish products investigated (9 groups of Danish edible fish). I have generally applied system expansion for co-product allocation, and mainly used two databases: ETH-ESU-96 and the new LCAfood database (see www.lcafood.dk). The method used for LCIA is the Danish EDIP 97-update, but the results are verified by Ecoindicator 99 and CML. The study include future scenarios. The study unveils that the fishery stage is the hot-spot for the impact categories considered, but the use- and retail stage also represents a noticeable impact potential. It is remarkable that the processing stage has a very small impact potential in most cases. This also applies to waste water emissions, which has been the emission that so far has been mostly addressed by Danish environmental authorities, considering the life cycle of fish products. The fuel consumption in the fishery can be very high in some cases, and flatfish caught with beam trawl represents a fuel consumption of more than 3 litre per kg caught flatfish (roughly 10 litre per kg consumed flatfish filet), while Danish seine can catch the same fish with a fuel consumption that is nearly 20 times smaller. Thus, if we consider the whole life cycle and impact categories such as global warming, ozone depletion, acidification, nutrient enrichment and photochemical ozone formation we can actually obtain a factor 4-5 improvements by substituting beam trawl with Danish seine. However, the emissions of anti fouling agents are very small for beam trawlers, and we actually have a considerably larger contribution to eco-toxicity for the Danish seine. However, in future scenarios it is most likely that this advantage of beam trawl will be greatly reduced or oven disappear. Considerable improvements can also be obtained by substitution of trawl and beam trawl for other species as well, and generally we will obtain reduced impacts on the seabed at the same time. Thus, it is recommended that the authorities address energy consumption at the fishery stage much more. This could be done by development of cleaner production at the primary stage, eco-labelling, fuel tax and much more.

LCA on Danish fish products



Mikkel Thrane (Ph.D candidate)
Aalborg university

LCA on Danish fish products

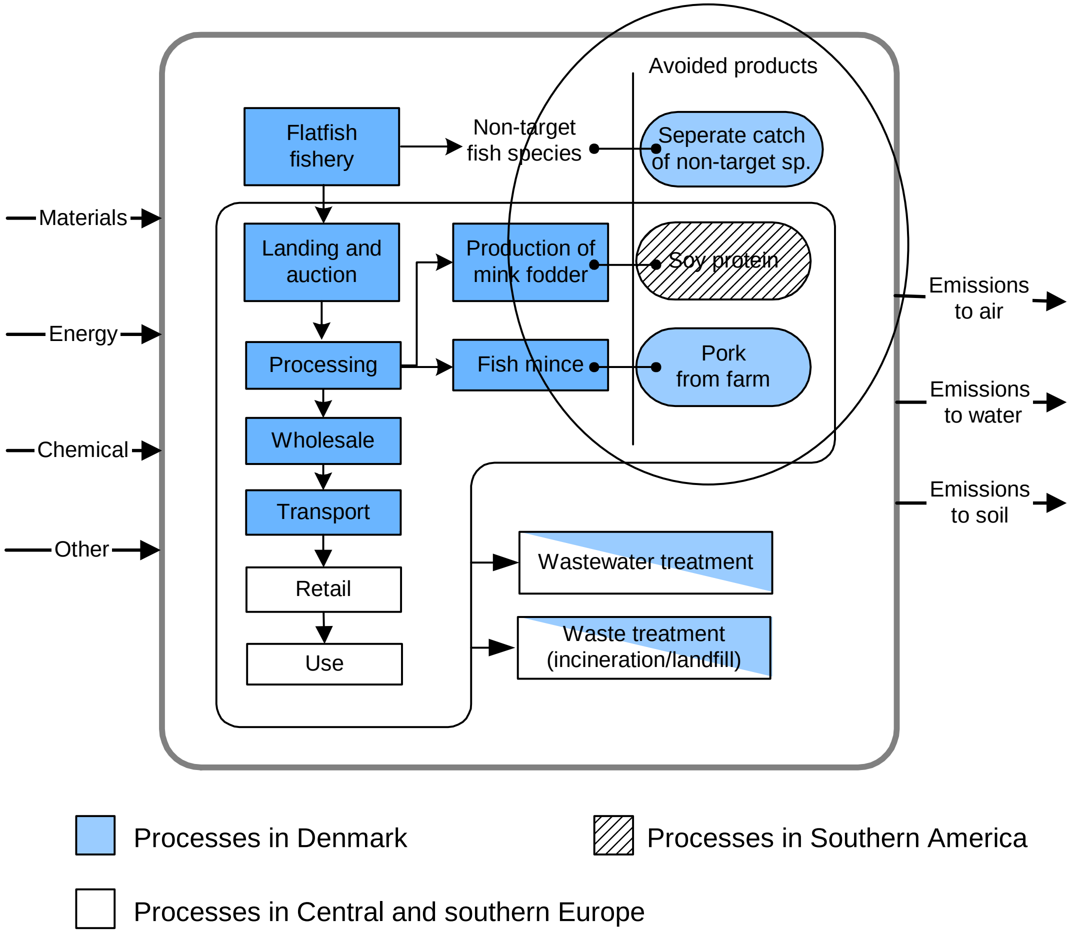
1. Methodological aspects
2. Method applied for co-product allocation
3. Key inventory results for energy
4. Characterization results (Flatfish)
5. Weighted results (Flatfish)
6. Conclusions

Methodological aspects

- Approach: Change oriented LCA
- Co-product allocation: System expansion
- Database: ETH-ESU 96 and LCAfood database (www.lcafood.dk)
- LCIA method : EDIP-97 update

  (Ecoindicator 99 and CML as verification)

….continued (process diagram flatfish)



How does system expansion work?

- Danish fishery divided in five vessel segments
- Each segment is defined on the basis of its target fish (most cases 2/3 of the catch value)
- Thus, we have five segments targeting five different target species
- We therefore have a matrix with five vessel segments and five target fish
- We also know the fuel consumption per kg mixed fish in each segment
- Thus, we just solve the 5x5 matrix equation

Fuel consumption for codfish:

	Codfish Vessel	Flatfish vessel	Norway l vessel	Pelagic vessel	Trash f. vessel	Wanted Output
Fuel consumption (l/kg mixed fish)	0,5	0,8	1,4	0,18	0,07	
Codfish (kg)	40	12	33	13	1	1
Flatfish (kg)	14	50	23	2	3	0
Norway lobster (kg)	10	3	45	3	2	0
Pelagic fish (kg)	5	23	3	80	24	0
Industrial fish (kg)	3	2	2	23	90	0
Output (kg)	A1	A2	A3	A4	A5	Sum = 1kg codfish
Fuel consumption (liter)	**A1*0,5**	**A2*0,8**	**A3*1,4**	**A4*0,18**	**A5*0,07**	**Sum = x liter per kg codfish**

….similar for flatfish etc.:

	Codfish Vessel	Flatfish vessel	Norway l vessel	Pelagic vessel	Trash f. vessel	Wanted Output
Fuel consumption (l/kg mixed fish)	0,5	0,8	1,4	0,18	0,07	
Codfish (kg)	40	12	33	13	1	0
Flatfish (kg)	14	50	23	2	3	1
Norway lobster (kg)	10	3	45	3	2	0
Pelagic fish (kg)	5	23	3	80	24	0
Industrial fish (kg)	3	2	2	23	90	0
Output (kg)	B1	B2	B3	B4	B5	Sum = 1kg flatfish
Fuel consumption (liter)	**B1*0,5**	**B2*0,8**	**B3*1,4**	**B4*0,18**	**B5*0,07**	**Sum = x liter per kg flatfish**

Energy consumption for nine species

(- obtained by subdivision of categories)

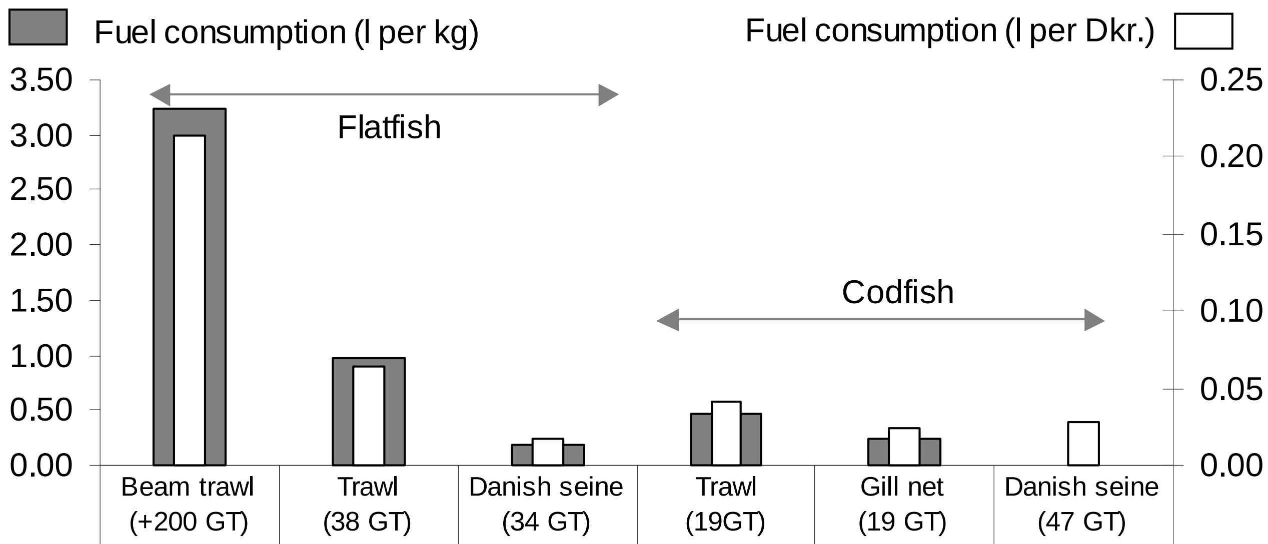
	Demersal fish		Shellfish				Pelagic		Indus.
Allocation method	Atlantic cod	Eu. Plaice	Prawn	Shrimp	NL.	Mus-sels	Herring	Mack-erel	Sand-eel etc.
	Total catch volume (1000 ton)								
	67.80	40.74	5.72	2.58	5.04	109.74	134.96	34.27	1,117.71
	Relative fuel consumption - per caught fish (liter per kg)								
Mass	0,47	0,56	0,54	1,02	1,16	0,01	0,14	0,08	0,10
Value	0,86	0,92	0,89	1,22	3,95	0,08	0,07	0,27	0,04
Sys. Exp.	0,36	0,97	0,76	1,03	6,05	0,01	0,18	0,06	0,06
	Absolute fuel consumption per caught fish (million liter)								
Mass	31.780	22.754	3.115	2.629	5.864	1.378	19.009	2.891	107.692
Value	58.245	37.565	5.068	3.149	19.929	8.233	9.791	9.263	45.870
Sys. Exp.	24.460	39.630	4.354	2.664	30.539	1.365	24.253	1.916	67.930

High

Low

More: Read article submitted to
The int. Journal of industrial ecology

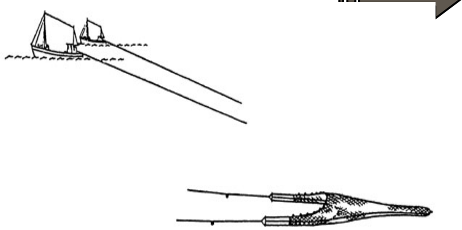
Some improvement potentials



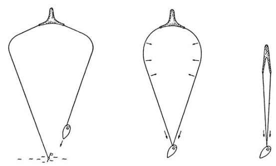
	Beam trawl (+200 GT)	Trawl (38 GT)	Danish seine (34 GT)	Trawl (19GT)	Gill net (19 GT)	Danish seine (47 GT)
Fuel consumption (l per kg)	3.23	0.98	0.18	0.46	0.24	-0.20
Fuel consumption (l per Dkr.)	0.21	0.06	0.02	0.04	0.02	0.03

A "factor 4" improvement is possible

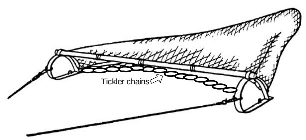
Bottom trawl



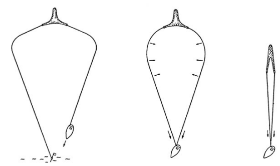
Danish seine

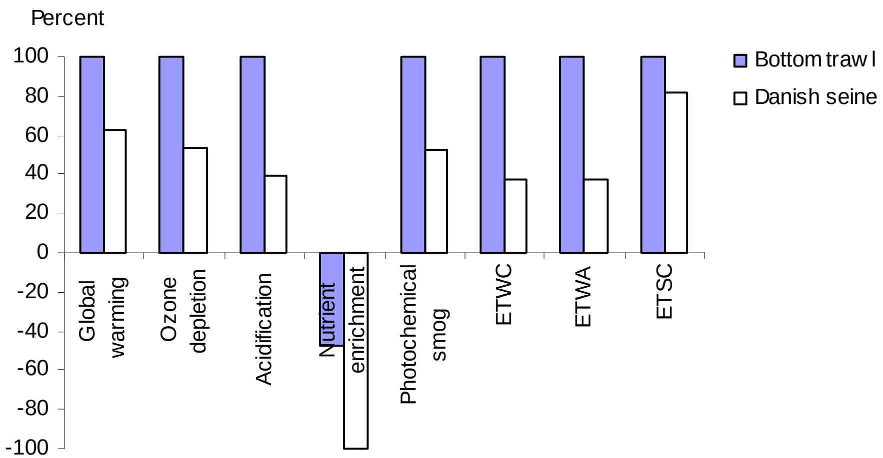


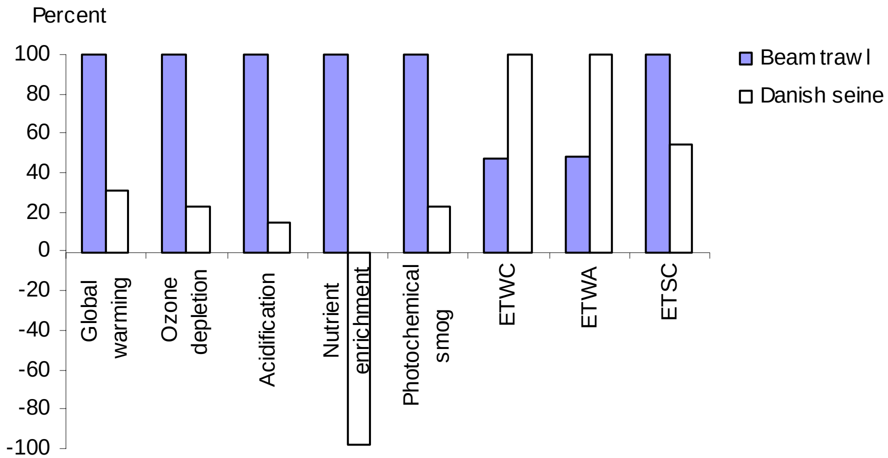
Beam trawl



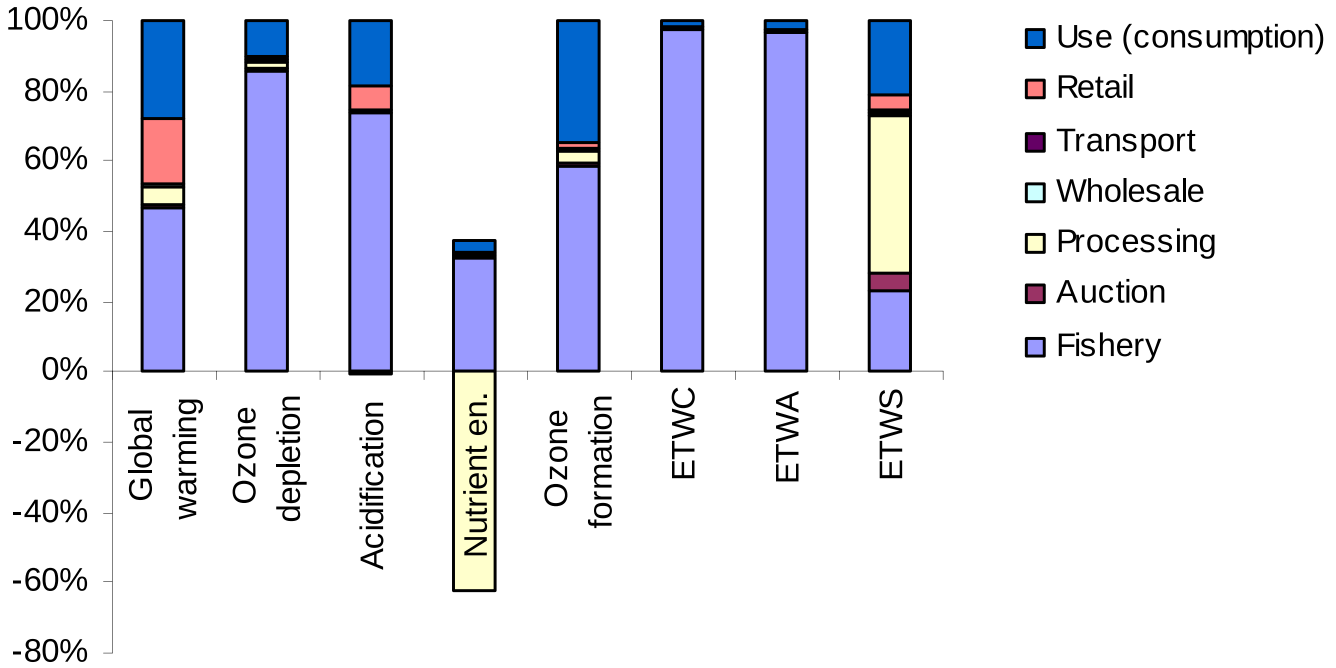
Danish seine



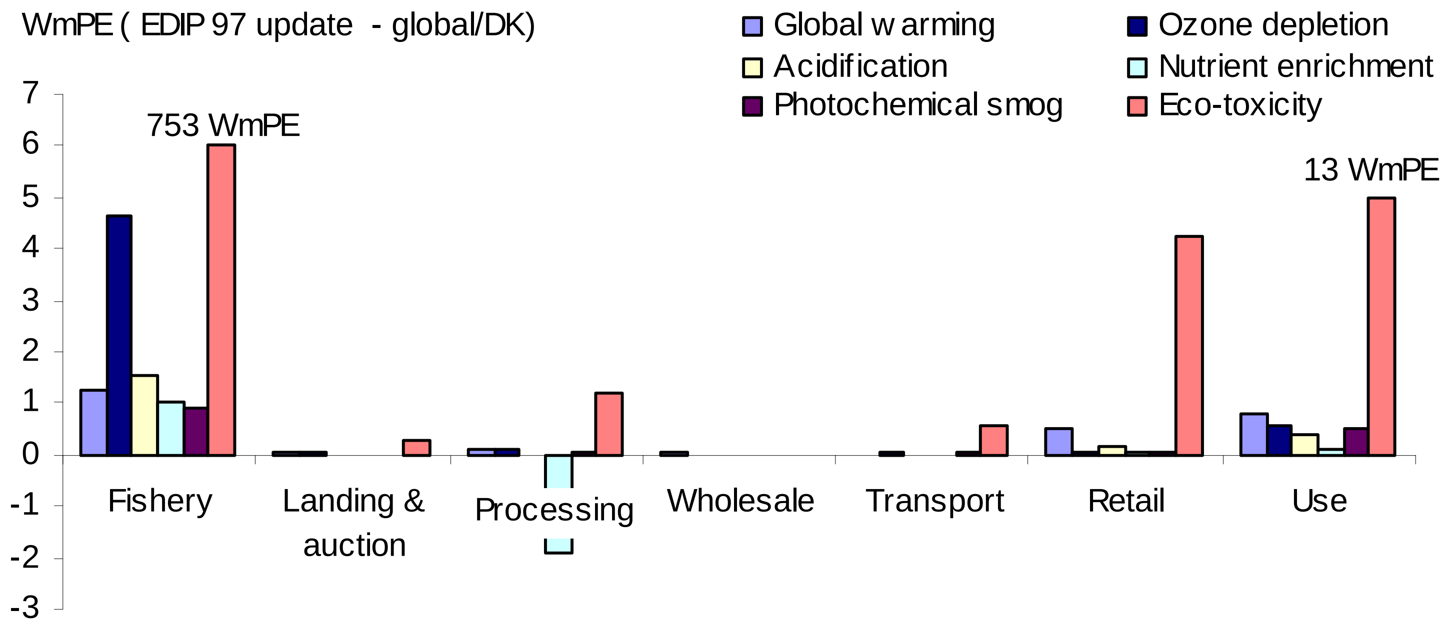




Characterization – flatfish filet (IQF)



Weighted results – flatfish filet (IQF)



Conclusions

- Quantitative LCA: The **fishery is hot-spot**, followed by use and retail (six categories)
- Qualitative LCA: The fishery is still the hot-spot (humtox, **seabed**, landuse, **waste, fish resources, by-catch & discard, non-renewable resources**, groundwater, **H&S, animal welfare**)
- **Energy consumption is a key process** for all seven impact types (even more in the future)
- Most important processes are, fishery, cold storing and transport Authorities need to address energy consumption and sea floor impacts (**Solve two problems by addressing one**):
  - Adjustments of the fleet capacity (maintain small vessels)
  - Env. Regulation / CT (not only processing stage)
  - Eco-labelling (not only focus on exploitation)
  - Fuel tax

5.4 Environmental effects of wild caught cod, farmed salmon and chicken – possible to compare?

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Tom Arne Pedersen, SINTEF Fisheries and aquaculture
Norway

Introduction

Environmental effects of food production are increasingly focussed, also when it comes to fish. Not only the content and the quality of the fish as food are important to the consumers. The environmental effects of how the fish is caught or produced, processed and brought to the marked are becoming important issues as well [Mandag Morgen MicroNews, 1998].

Environmental requirements are however not always easy to define or quantify, and for most customers environmental declarations will be impossible to re-examine. Development of objective criteria for what is environmental friendly and what is not are, or at least will soon be, important for the fisheries sector.

The purpose of this work has been to investigate the present situation with respect to environmental effects of production of fish and compare this with production of land based food. We have chosen to compare the environmental effects of wild caught cod, with farmed salmon and chicken. The point of departure has been fish, but comparison with chicken is assumed to be of interest as fillets of both cod, salmon and chicken are substitutes in the grocery cabinets. It should be a reasonable assumption that these foodstuffs easily can be selected at the sacrifice of the others if the choice is influenced by information regarding environmental effects.

In addition comes that production of land based food are often assumed to be more environmental friendly especially when it comes to energy consumption than production of sea food. In particular fishing with modern factory trawlers are often pointed out as energy demanding [Huse et. al, 2002].

The goal of the work

The work has had several goals:

1. Contribute to the make the sustainability concept more operable by searching for reference levels for environmental impacts within the fish and food sector.
2. Compare environmental effects of various food production chains and reveal whether there are representative differences between a catching and farming strategy and between sea and land based food production.
3. Reveal processes or activities that are systematically less environmental efficient than others that should be given more attention.

The goal has not been to pinpoint one of this food chains as less environmental efficient than the others, but to establish a better foundation for improvements and further analyse work.

The method

The work has as thoroughly as possible followed the steps described in the ISO 14040 standard [ISO, 2003] in order to make it both transparent and reproducible. The analysis has further followed the steps in the respective food chains. Much of these steps are more or less identical.

As functional unit (FU) is used one kg. fillet of wild caught cod, farmed salmon and chicken respectively. The cod is caught by factory trawler in the Norwegian fishery sector, the salmon is farmed on the west coast of Norway whereas the chicken is raised in the southern part of Norway.

The system boundaries include catching, breeding, farming and processing. This include both fishing and processing of industrial fish and grain production and processing as input to feed production. Environmental effects during wholesaling, retailing and the consumer’s final food preparation are however left out. Further packaging materials and waste treatment are excluded from the analysis. All transportation steps are however included. The system boundaries also exclude capital goods as buildings, trucks and fishing vessels. The phases and items left out are assumed to be of secondary importance except for the final food preparation that may contribute considerably as concluded by Carlsson-Kanyama et. al. [2001]. It follows that this preparation phase should be included in later work.

Data are collected from various sources by both literature surveys, study of available data sources, telephone conversations and meetings. Collected data was systematically put into so called MECO (Mass Energy Chemicals Others) diagrams as basis for further analyses. The LCA tool SimaPro was used in combination with the Eco-indicators 95 and 99 respectively.

Environmental challenges within the food chains in question

There are several environmental challenges within the food chains in questions. Within the cod fisheries, these are mainly connected to items like:

- Over-fishing.
- Energy use.
- Bottom effects from trawl gears and dredges.
- By catch of unwanted species, undersized fish, sea mammals and seabirds.
- Discards of unwanted species.
- Ghost fishing caused by lost gill nets.
- Unintended mortality caused by injuries imposed by fishing hooks, escape through selection grids and from gill nets etc.
- Use of anti fouling.

Within salmon farming these affects are mainly connected to:

- Energy use.
- Area effects on both sea and land.
- Eutrophication on both sea and land.
- Escape and genetic contamination.
- Salmon lice and effects on wild salmon.
- Effects on the biotope from medication and use of pesticides.
- Use of anti fouling.

Further to chicken farming environmental affects are mainly:

- Energy use.
- Effects of land use.
- Eutrophication effects.
- Effects on the biotope from medication and use of pesticides.
- Use of fresh water.

Most of the ecosystem properties effected directly or indirectly of the fishing or farming activities are influenced in a degree depending of both where and when the contamination takes place. It follows that it is seldom possible to establish direct connections between these activities and environmental effects. An analysis of environmental performance will have to be based on some selected effects that may be used as indicators more as basis for trend analyses than to find absolute answers. This analysis is thus based on some selected effects considered to be of importance and also considered to form a possible basis for comparison.

One such item is the energy consumption. As a general rule, it may be assumed that a high energy consume also indicates a high score within other environmental performance factors although this is not always the case.

Further the eutrophication effects from use of fertilisers within grain production on land are included whereas direct eutrophication effects from salmon farming are neglected. This is clearly a simplification, but Norwegian salmon farming normally takes place at locations with good water replacement where eutrophication is considered to be of minor importance. The eutrophication effects are estimated using Eco-indicator 95 both with ammonia as NH3 and as ammonia.

Land use effects of crop production and bottom trawling are finally assessed by use of Eco-indicator 99. For agricultural production of crop, damage factors for land occupation are used. As there is not available any indicator covering effect on the sea bottom, damage factors for land conversion is used as if this took place on land. The area affected by the bottom gear of the trawl is estimated pr. kg. fish caught. The bottom effect is calculated for several scenarios as a sensitivity analysis. It is assumed that 1% and 10% respectively of the area covered by the bottom gear is affected with respect to reduction in biodiversity. Further recreation times, or the time it takes for the affected area to recover back to its original or undisturbed state, are assumed to 1 week, 1 month and 6 months respectively.

The results
The results show clearly that it is the fishing activity for cod and the farming activities both for salmon and chicken that are the main contributors to the environmental effects. For the cod chain this is due to the energy consumption during fishing and for salmon and chicken this is due to the production of the feed.

When comparing the environmental effects of the functional units due to energy consumption, chicken production is the most effective followed by cod fishing with salmon farming as the less energy effective production.

Eutrophication effects due to land based crop production affect this picture as chicken farming is heavily based on grain products produced on land. Still the chicken farming turns out to be more eco-effective than salmon farming even when this effect is taken into account.

Depending on the presumptions, land use effects however show considerable effects on the eco-system. These effects are estimated using Eco-indicator 99. Assuming that only 1% of the over-trawled area is affected and this is recovered after 1 week, this effect is negligible for cod fishing. On the other hand, assuming that 10% of the area is affected and the recovery time is 6 month, the effect is totally dominating the environmental effects of bottom trawling.

Further land effects due to land based grain production effect the environmental efficiency of chicken production more than salmon farming due to the feed content. This observation may be of limited value, but the future supply of marine based feed for the aquaculture industry may be limited.

Separate calculations were further done to compare the eco-efficiency of salmon production based on normal salmon feed with salmon produced based on feed where fish meal and fish oil is substituted with corn products. This was done using both Eco-indicator 95 and Eco-indicator 99 to examine the impacts of energy use first and then afterwards include the land use effects. The results show that replacing of the marine content in the salmon feed with grain based products will reduce the energy needed to produce the feed. Overall environmental effect of such a strategy may however be questioned when taking land use effects into consideration. The marine based feed is mainly produced based on pelagic and not ground fish caught without any contact with the fishing gear and the sea floor. Land use effects are on the other hand of relevance when it comes to growing of grain products.

Discussion
Comparing environmental effects of different products is a questionable business, but such kind of investigations may turn out to be requested as basis for future environmental labelling etc. To achieve an objective basis for such comparisons, improved standards of reference or Eco-indicators should be developed.

The results are also highly dependant of what effects that are taken into consideration. Comparison based on energy use is most reliable while other effects should be compared with care. The results also seem to be more reliable when comparing salmon versus chicken or within the farming business. To compare environmental effects of fishing with farming is complicated except for the energy consumption.

Land use effects show however great impacts, but need to be substantiated especially when trying to estimate these effect in connection with bottom trawling.

An interesting conclusion is however that the "vegetarian salmon" may not be an environmental friendly alternative when taking land use effects into consideration.

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Environmental effects of wild caught cod, farmed salmon and chicken. Possible to compare?

Presentation NARP meeting

Monday 10. nov. 2003

Trondheim

By

Harald Ellingsen, SINTEF Fisheries and aquaculture and

Tom Arne Pedersen, Fisheries and aquaculture

Environmental effects of wild caught cod, farmed salmon and chicken

- Comparison of 1. kg. fillet of all 3 products (functional unit)
- Following the food chain to the consumer
- Use of Simapro and Eco-indicators 95 and 99
- Capital goods as buildings, trucks and fishing vessels are excluded
- Consumer’s final food preparation are left out
- Analysis according to the ISO standard

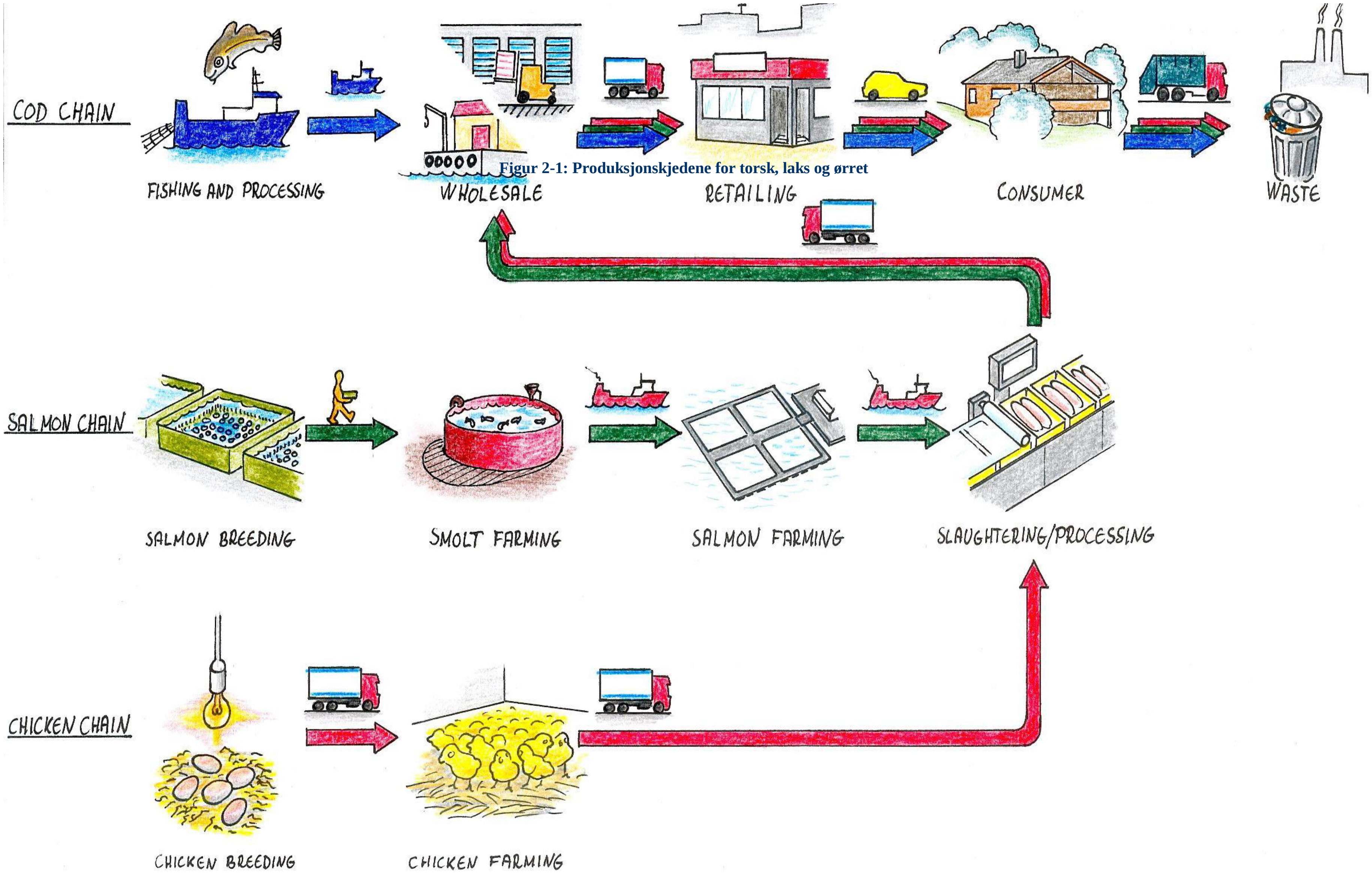
Purpose of analysis

- Contribute to the make the sustainability concept more operable by searching for reference levels for environmental impacts within the fish and food sector
- Compare environmental effects of various food production chains and reveal whether there are representative differences between a catching and farming strategy and between sea and land based food production
- Reveal processes or activities with systematically larger environmental impact that should be given more attention (hot spots)

Any purpose to compare?

- Cod, salmon and chicken are substitutes in the grocery shops
- Environmental score may influence the customers choice
- Similarities w.r.t. steps in the food chains
- Both salmon and chicken eat soy, wheat and fish (marine food)
- The production of both soy and marine fat is on its limits

Production chains - cod, farmed salmon and chicken



Environmental challenges within the food chains in question

Cod fishing

- Over-fishing
- Energy use
- Bottom effects
- By catch
- Discards
- Ghost fishing
- Unwanted mortality
- Anti fouling

Salmon farming

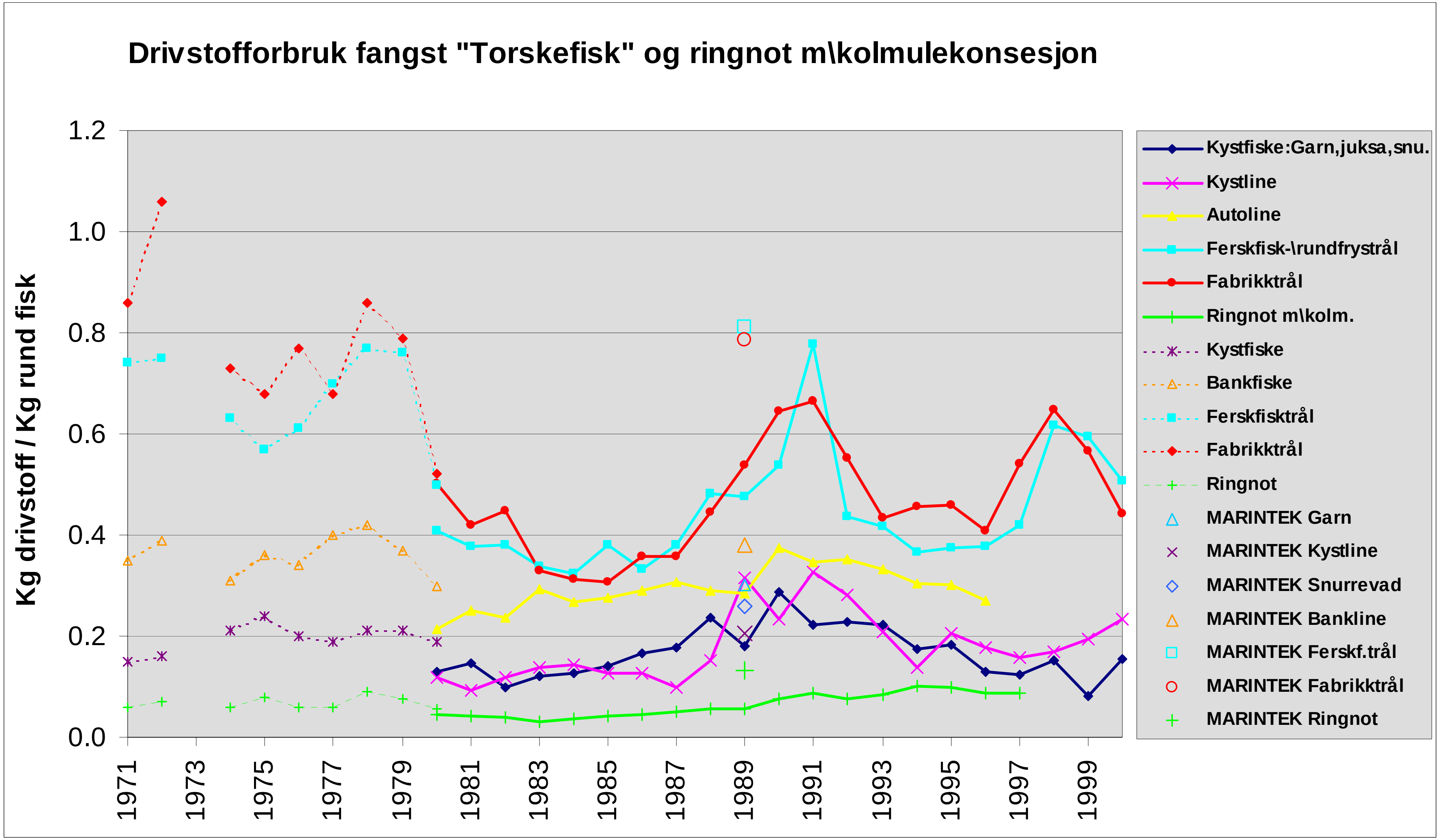
- Energy use
- Land use
- Eutrofication
- Escape
- Salmon lice
- Medication
- Pesticides
- Anti faouling
- etc.

Chicken farming

- Energy use
- Land use
- Eutrofication
- Medication
- Pesticides
- Use of water
- etc.

Analysis progress:

- Eco-indicator 95 based on energy consumption
- Eco-indicator 95 with eutrofication
- Eco-indicator 99 with land use



Sources: Budsjettnemdas Lønnsomhetsundersøkelser, Statoil, Norsk Petroliumsinstitutt, BunkerOil, Toll- og Avgiftsdirektoratet, MARINTEK, FTFI økonomigruppen, Fiskeridirektoratet, Norsk institutt for landbruksøk. forskning

Energy use – examples form Nordic countries

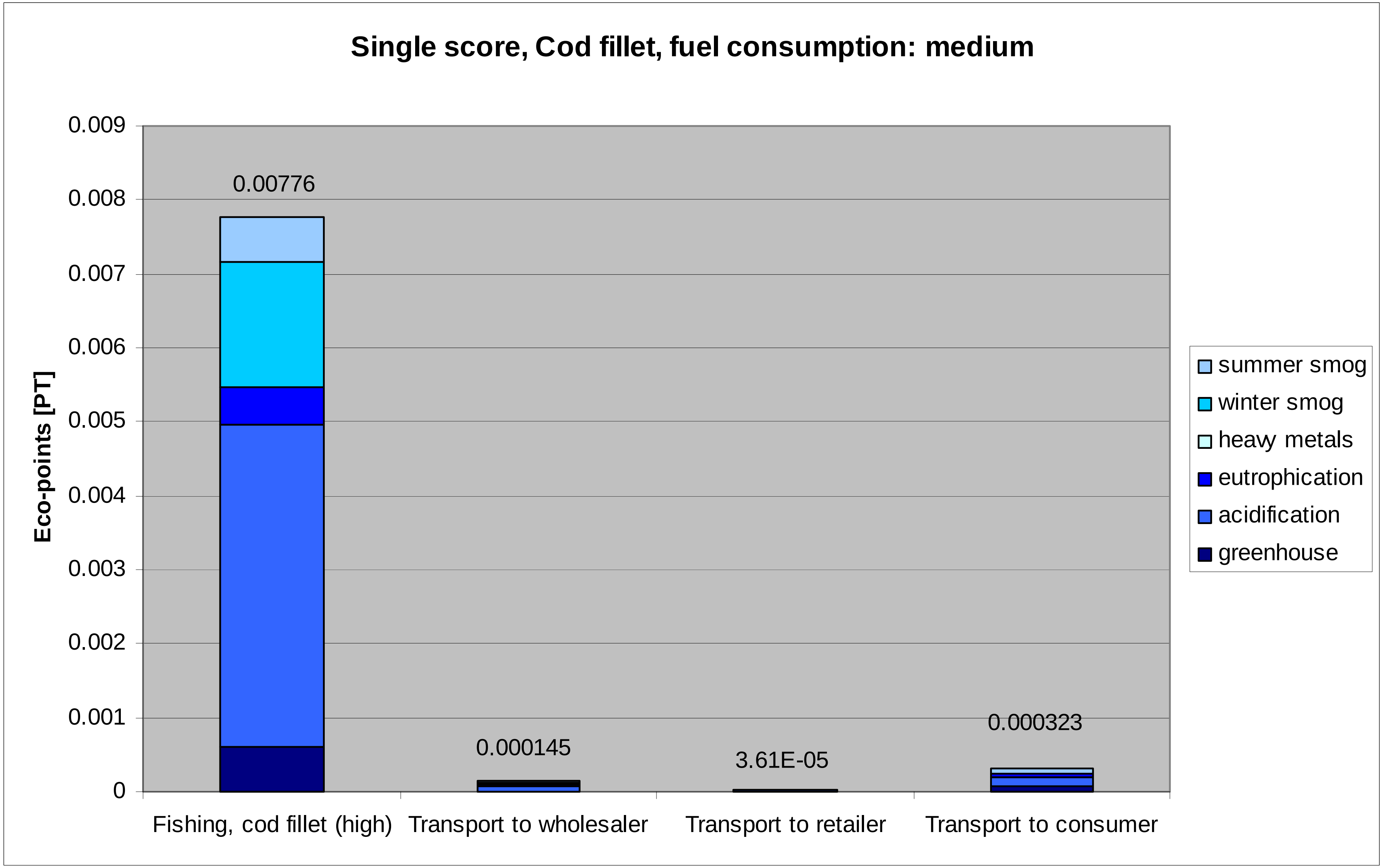
Fiskemetode	Drivstoffkoeffisient [kg drivstoff/kg fisk]				
	Islandsk fiske	Svensk fiske (Ziegler 2001)	Dansk fiske (Bak 1994)	Norge (Meltzer og Bjørkum år 89)	Norsk fiske (denne undersøk.)
Bunntrål, hav	1,0			0,81	0,47
Bunntrål kyst	0,6	1,5	1,4	0,79	0,44
Autoline, hav	0,3			0,36	0,29
Autoline, kyst	0,2			0,21	0,18
Kystfiske	0,1	0,41	0,33	0,25	0,17
Ringnot (sild, lodde)	0,04			0,13	0,06
Ringnot (kolmule)	0,09				

Salmon feed content

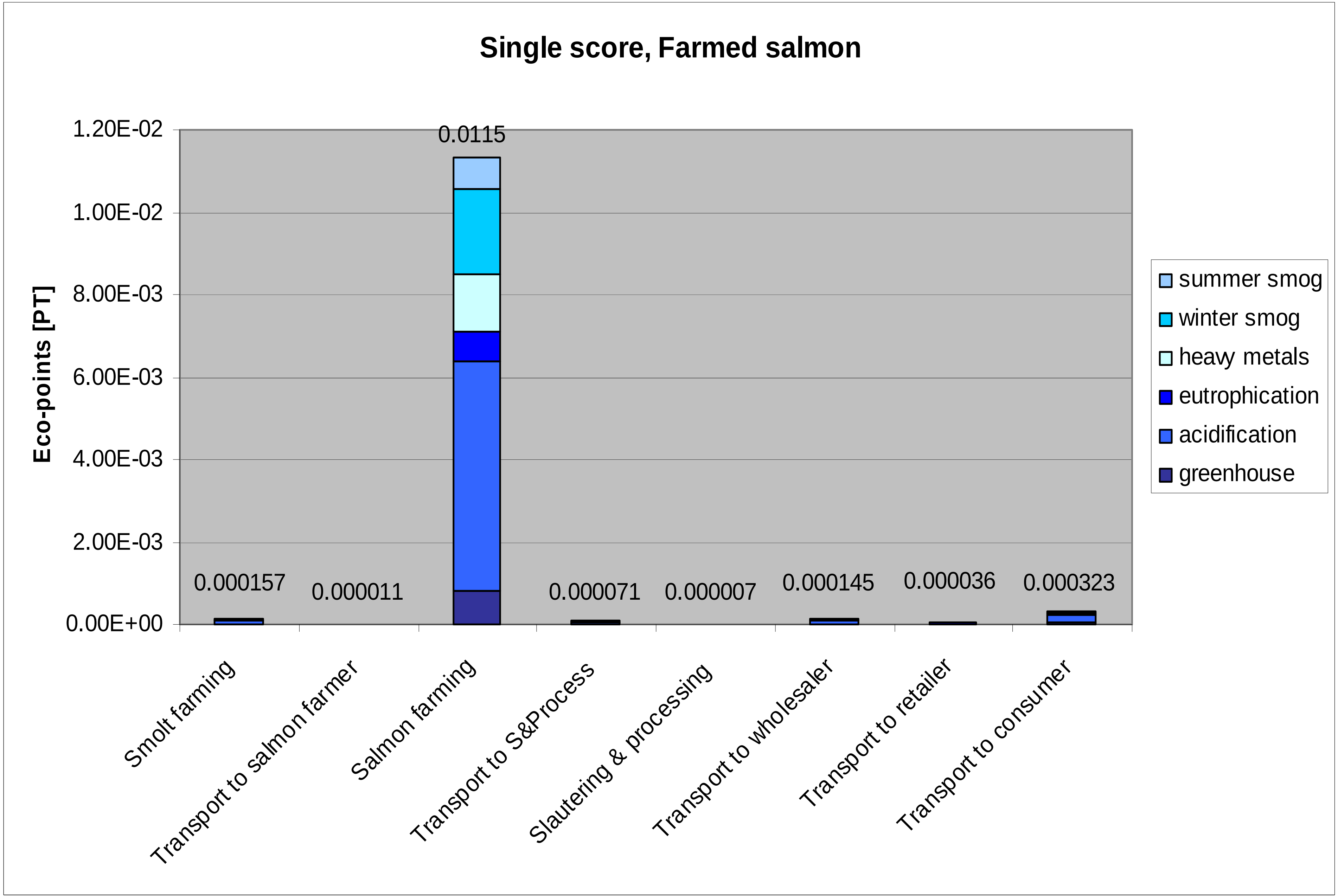
Ingredient	g/kg dry feed
Fsh meel	350
Fish ensilage	50
Maize- and wheat gluten	70
Soy products	60
Fish oil	280
Soy oil	30
Wheat flour	120
Various minerals, vitamins and color	40
Sum	**1000**

Chicken feed content

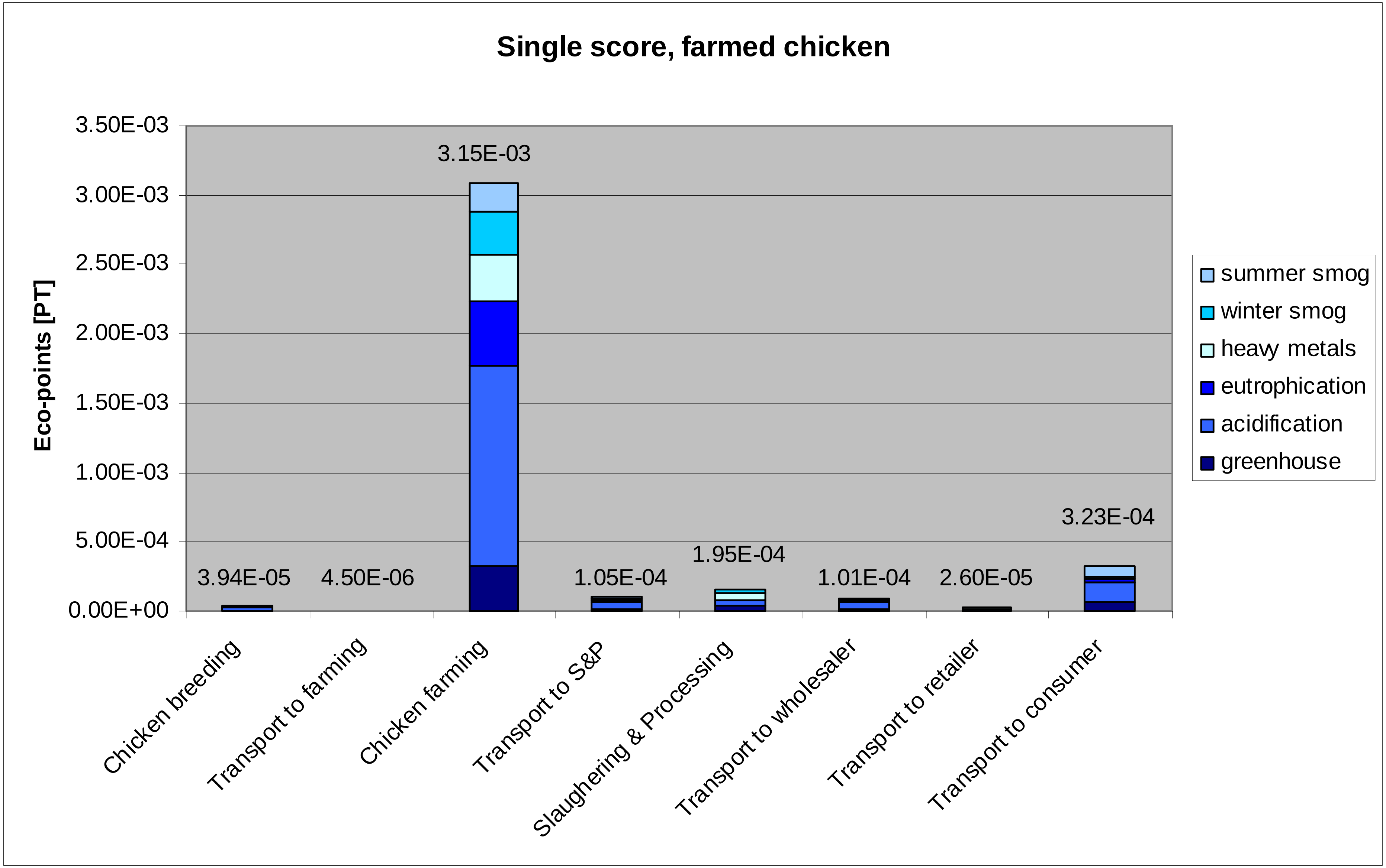
Ingredient	Percent (in weight)
Fish meal	0 – 5%
Oat	10 – 30%
Wheat	20 – 40%
Maize	10 – 30%
Rape meal	0 – 5%
Soy meal	5 – 15 %



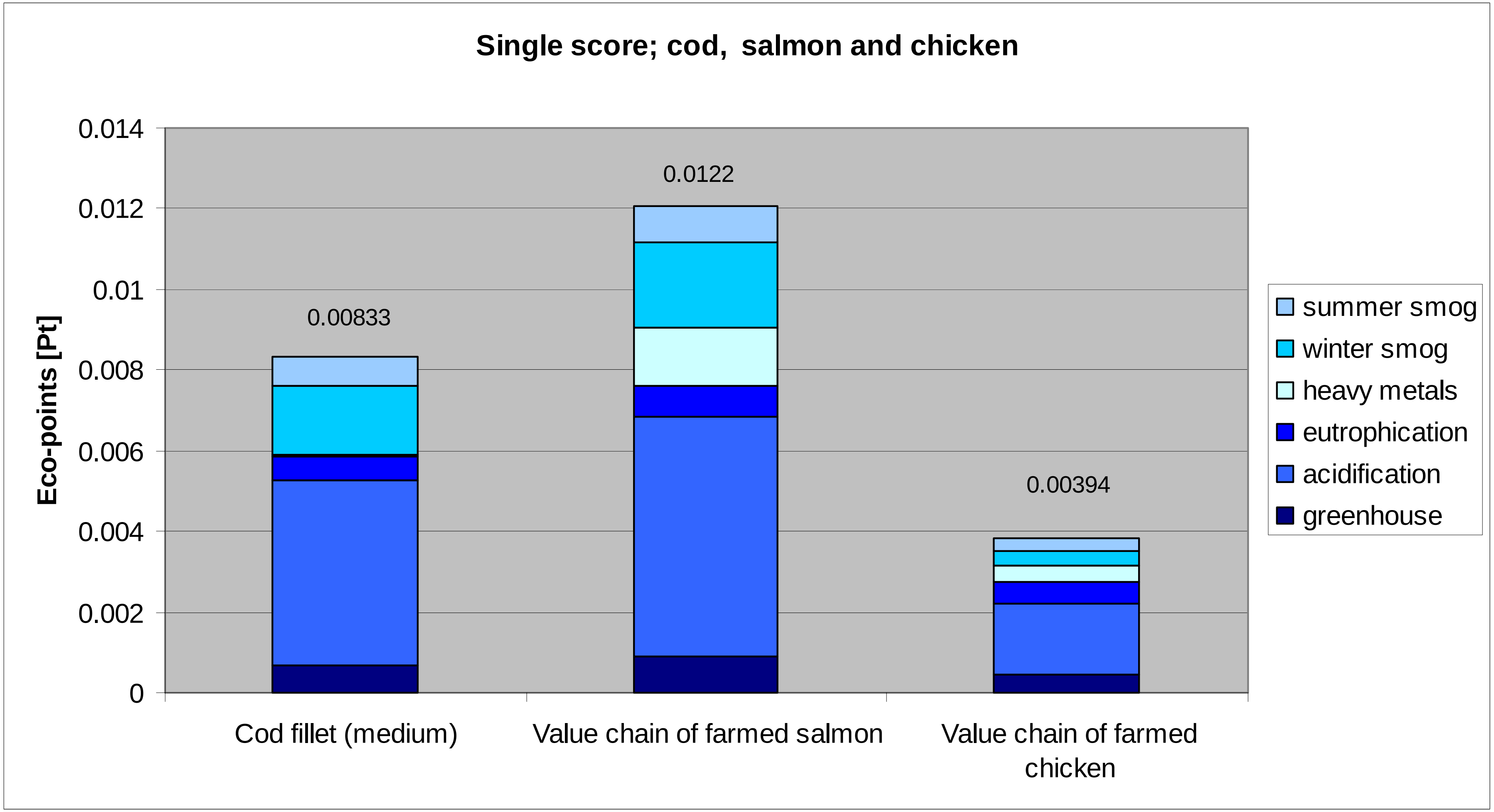
(Eco-indicator 95)



(Eco-indicator 95)

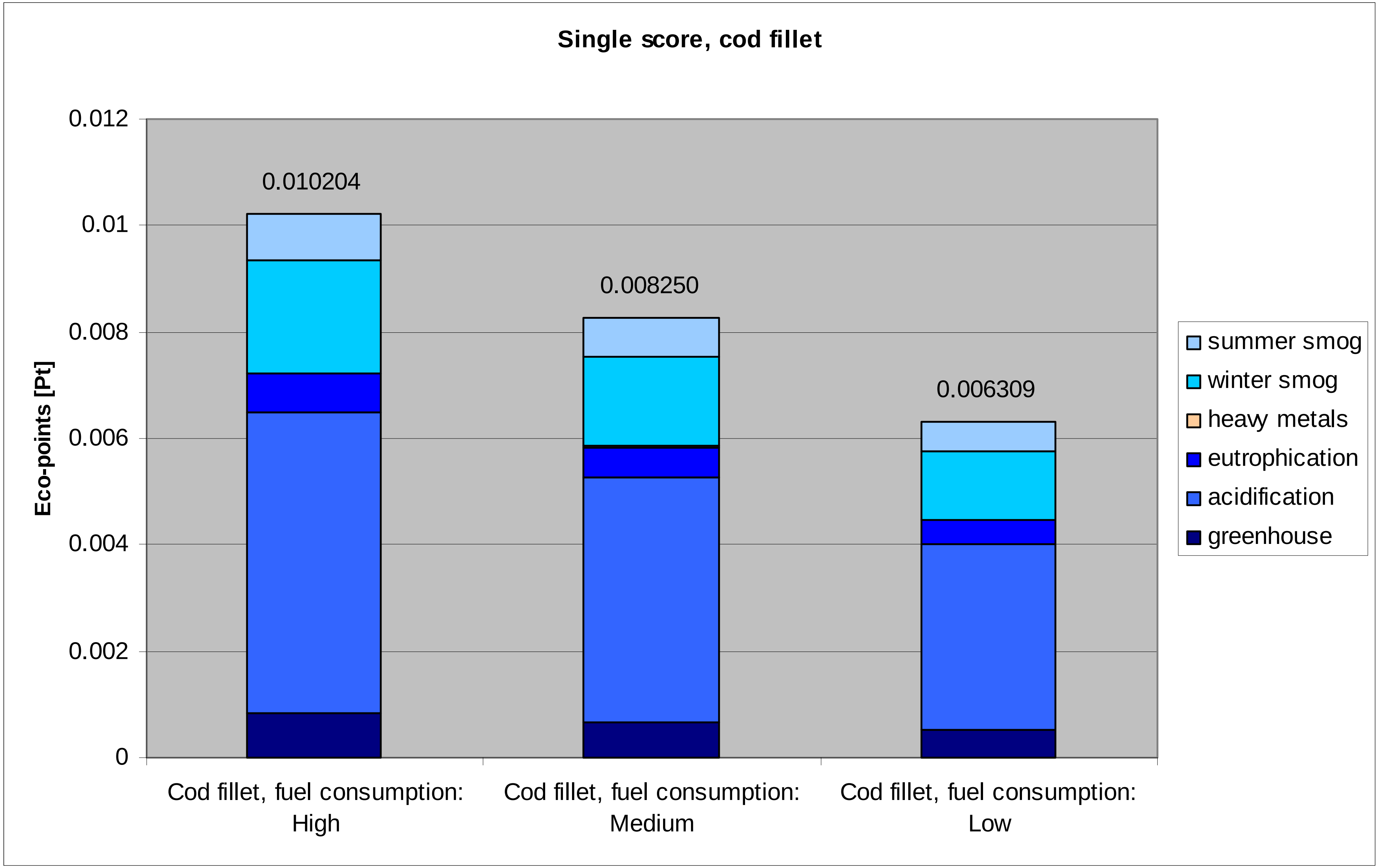


(Eco-indicator 95)

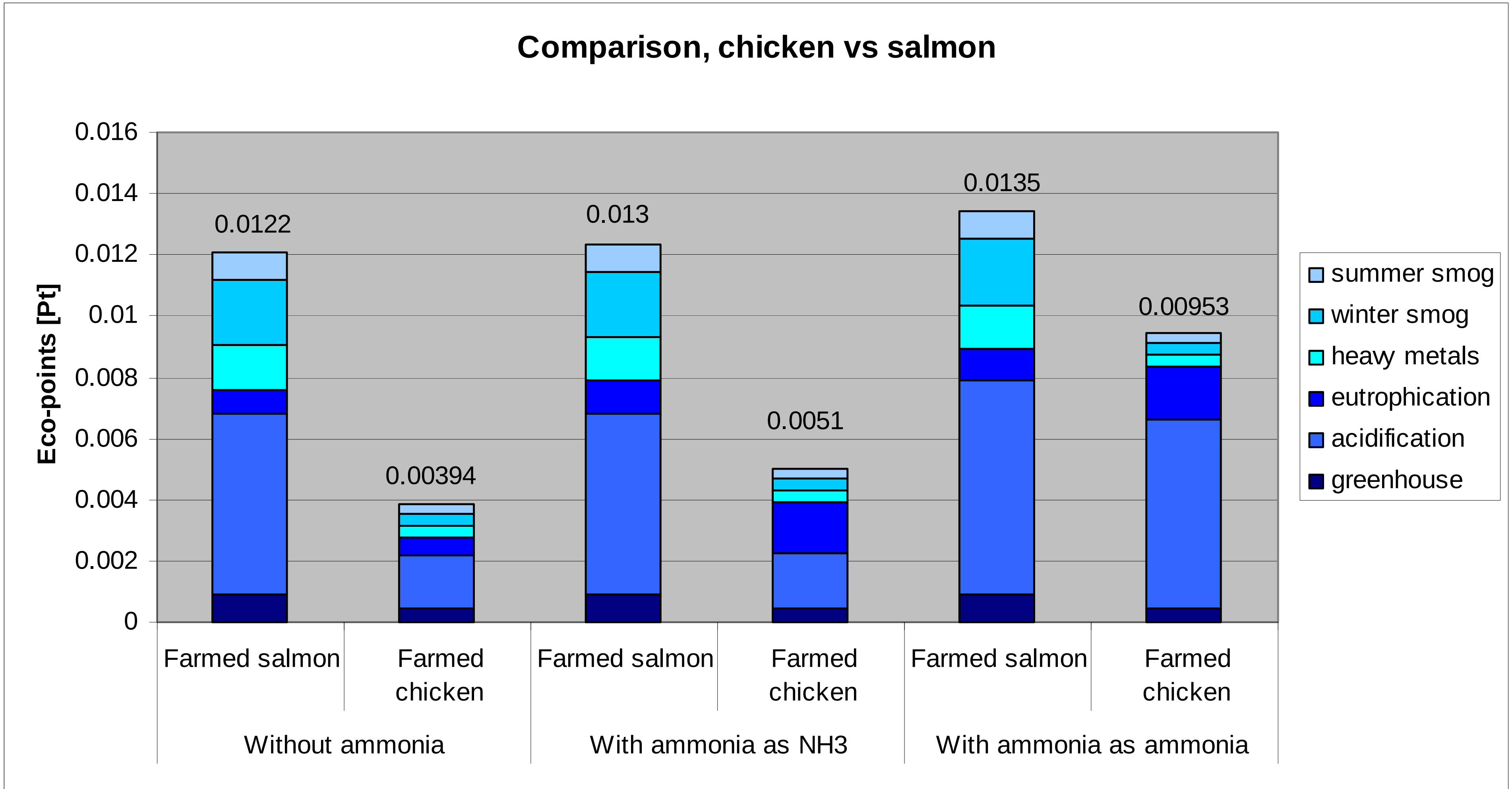


(Eco-indicator 95)

Total environmental load from production of 1 kg cod fillet with varying energy consume of 0.5, 0.4 and 0.3 [kg. oil/kg. round fish] (*Eco-indicator 95)*

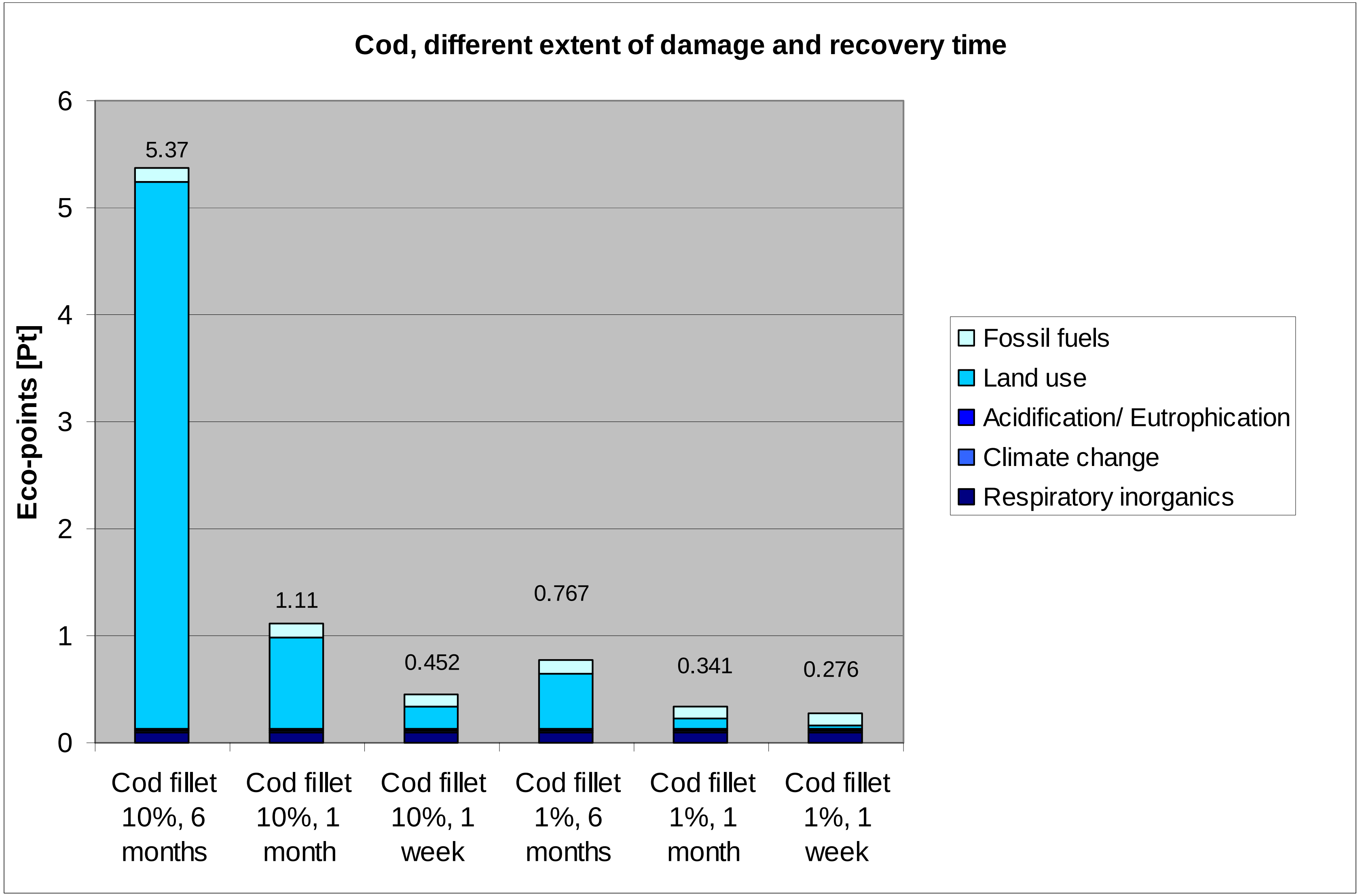


Total environmental impacts of salmon and chicken production including eutrophication effects in grain production *(Eco-indicator 95)*

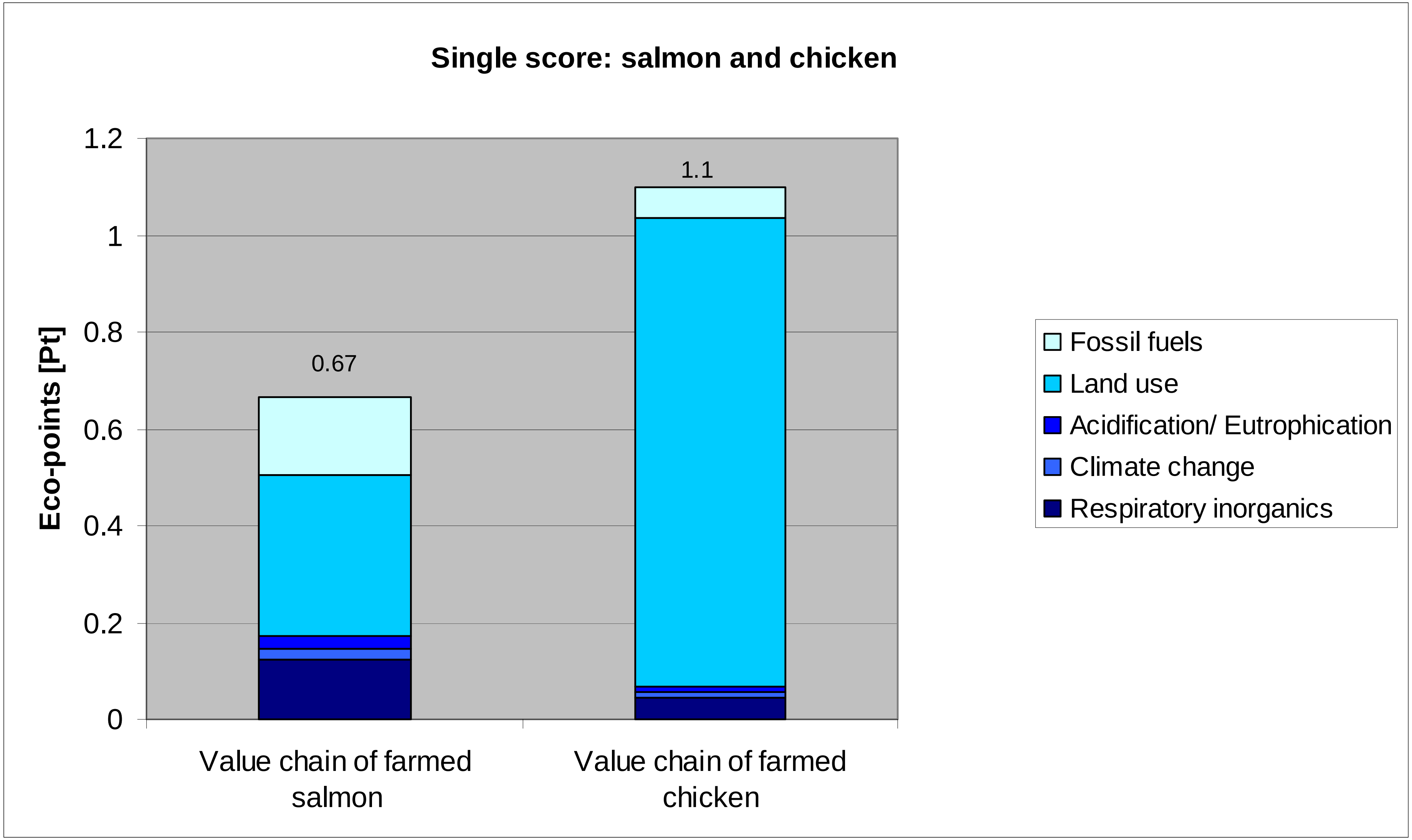


Calculation of area affected during bottom trawling	
Input data	
Trawling speed	4 knots
Time spent trawling	50% of total time sea
Catch rate pr. day	15 tons/day
Breath, trawl opening	65 m.
Conversion factor	3,25 (filet without skin and bones, mechanical processing)
Calculations	
Area covered pr. hour	481.478,4 m2
Catch rate pr. hour	1,25 tons/hour trawling
Bottom area covered pr. kg. fish caught	**385 m2/kg round fish**

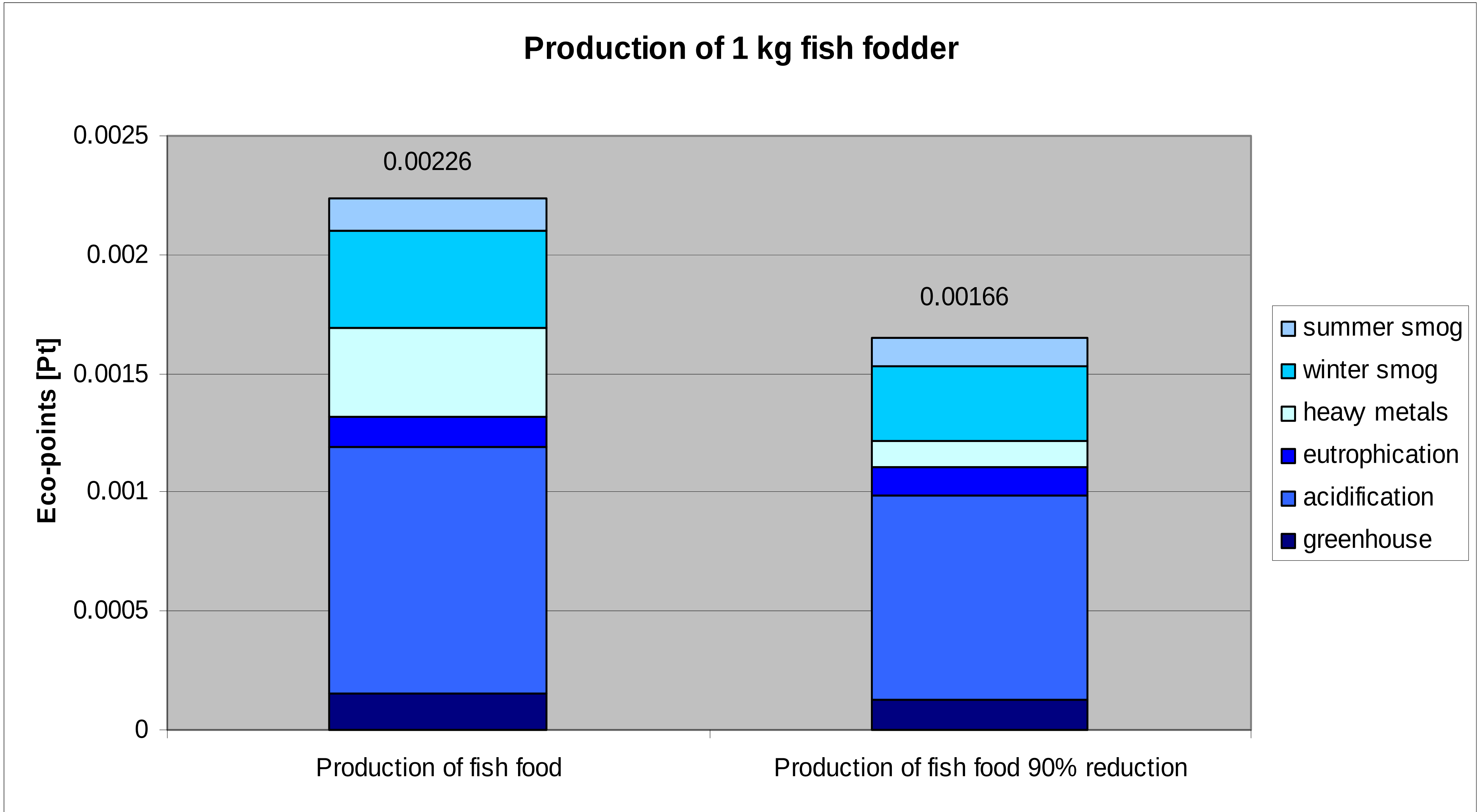
Environmental effects of cod fishing including simulation of on sea bottom from trawling based on indicators from land use with varying levels of disturbance and recovery times. *(Eco-indicator 99)*



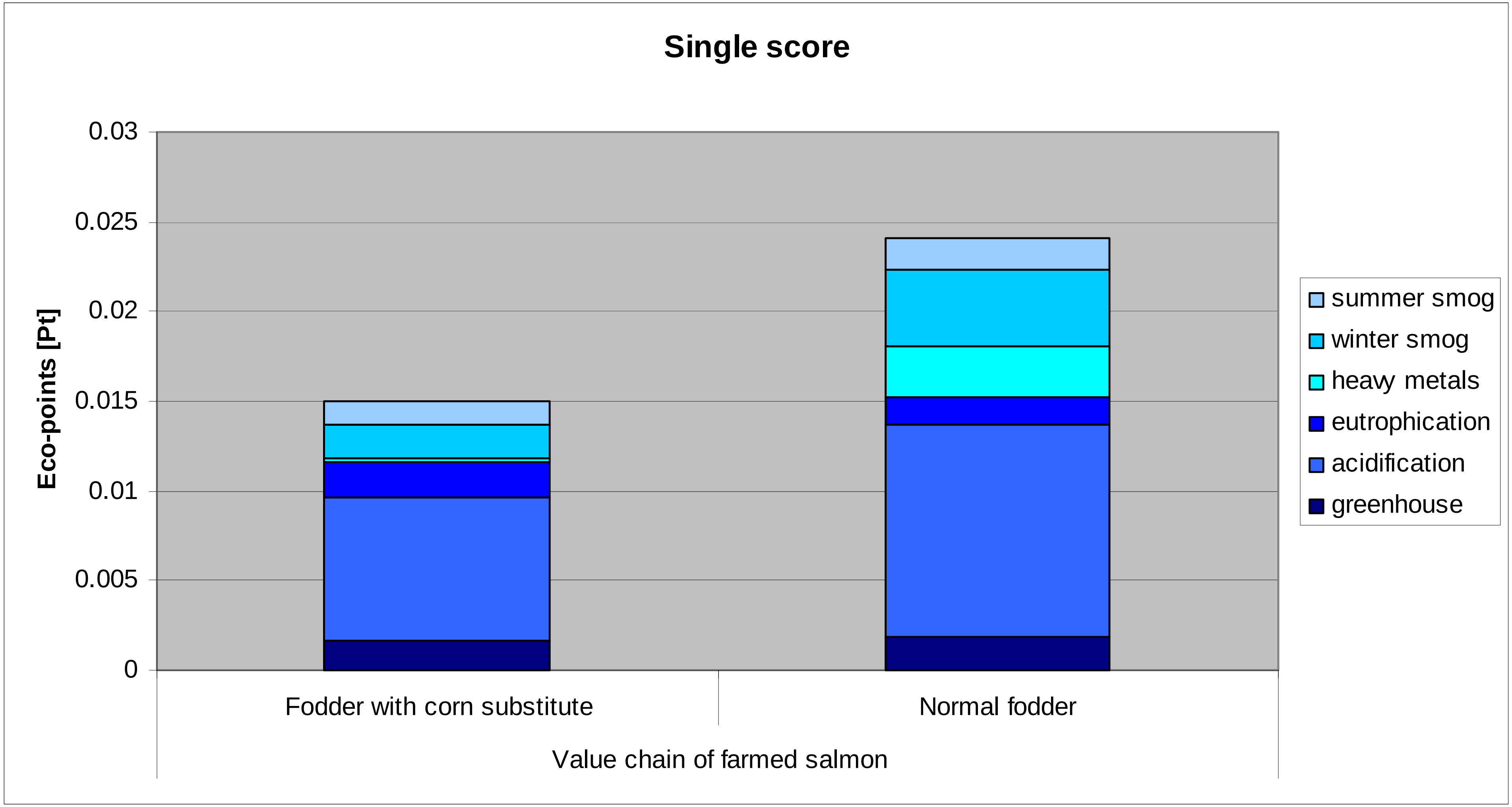
Single score including energy, eutrophication and land use effects, salmon and chicken *(Eco-Indicator 99)*



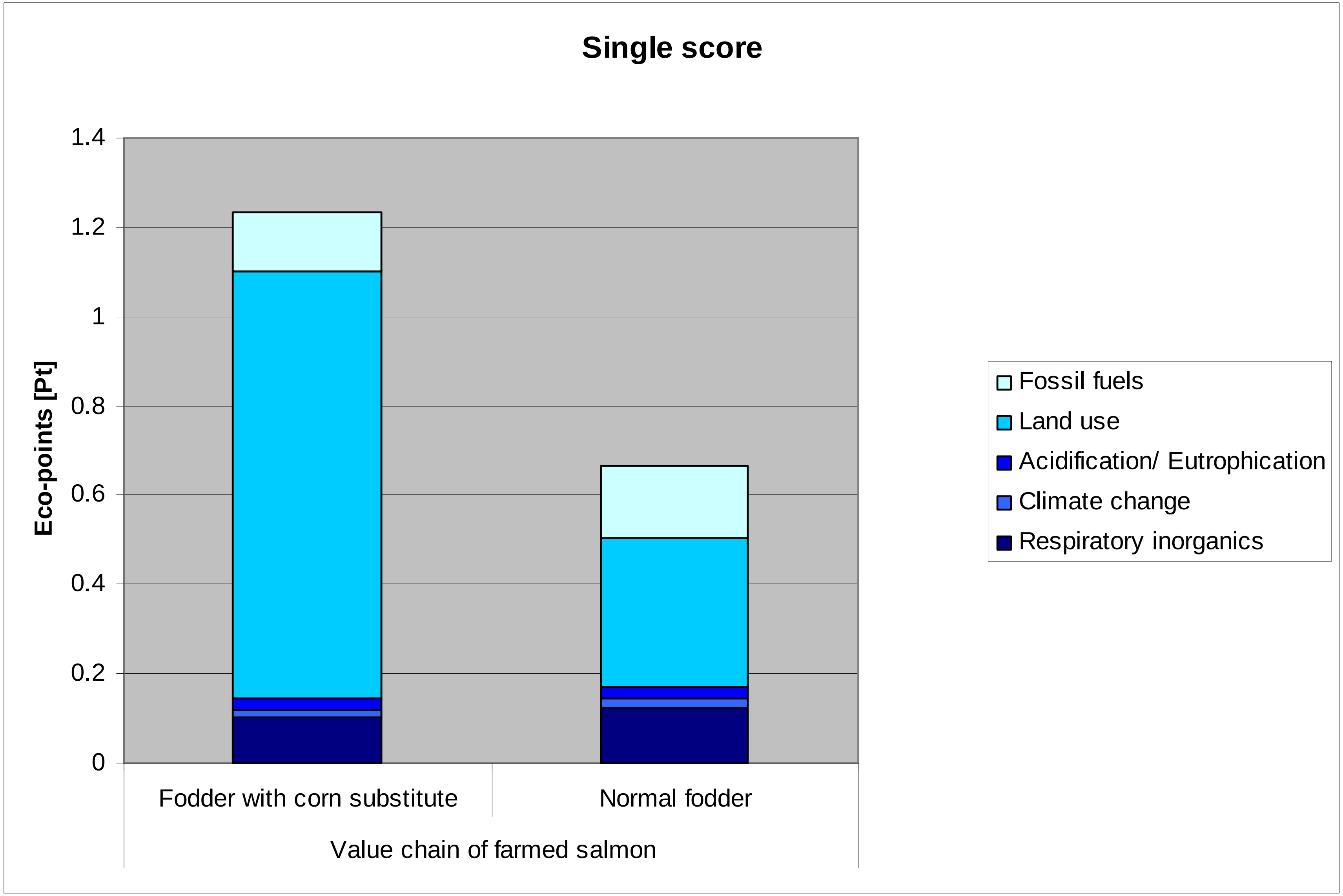
Environmental load from salmon farming based on normal feed compared to ”wet” feed (90% reduction in energy use for drying). (*Eco-indicator 95)*



Environmental load – ”vegetarian salmon” versus salmon raised by normal marine based feed. (*Eco-indicator 95)*



Environmental load including land use effects – ”vegetarian salmon” versus salmon raised by normal marine based feed. (*Eco-indicator 99)*



Some conclusions

- Conclusions highly dependant of which effect to be taken into consideration
- Comparison based on energy use most reliable
- Other effects to be compared with care – if at all
- More reliable results salmon versus chicken or within the farming business
- Land use effects have great impacts, but need to be substantiated
- Improved purpose adapted indicators are most wanted
- The “vegetarian salmon” may not be environmental efficient

5.5 Fishing activity and ecosystem effects

Irene Huse
Fish Capture Division
Institute of Marine Research
Bergen, Norway

Gislason summed up the ICES/SCOR Symposium on "Ecosystem Effects of Fishing" and pointed out that the indicators and reference points for ecosystem objectives for target and by-catch species (the directly impacted species) are well established. They include measurements of exploitation rate, spawning stock biomass and distribution. Also biological diversity and ecological functionality have been given candidate metrics (see ICES CM 2001/ACME:09). But to measure for example unaccounted mortality in fisheries is both complicated and complex. The fisheries are often multispecies and multifleet. The methods to study survival rates for fish that escapes from selection in trawls are complex and this is reflected by the large variation of estimates presented in the literature.

The effect of active gears trawls and dredges are presented with conflicting results and conclusions. For a review, please refer to Løkkeborgs FAO Technical report "Impacts of trawling on benthic habitats and communities" (in press). Otter trawls, for example, can leave clearly marked furrows (5-20 cm) from the doors. These may disappear from 5 months (strong currents) to 18 months (sheltered areas) later. Beam trawls and scallop dredges will flatten irregular bottom topography, eliminate bioturbation mounds and faunal tubes, and penetrate from a few to 8 cm deep in the substrate. The biological impacts from otter trawling on sandy bottoms/high seas seems to give declines in some individual taxa but no evidence of large changes in benthic assemblages. On soft bottom most studies have been on shrimp and Nephros trawling, some small changes have been shown, but no clear and consistent effects. For hard bottom only few studies of otter trawling effects are known, showing clear effect on tall sessile invertebrates and a large proportion (15-67%) of animals damaged by the ground gear. Biological impacts of beam trawling and scallop dredging shows clear evidence of short-term effects, a decrease in number of species (20-80% decrease in abundance in some species), increase in some polchaete but no effect in areas subjected to natural disturbances.

Gillnets are lost due to gear conflicts, strong currents, rupture of buoy line etc., and these gillnets may continue to catch fish. High ghostfishing rates have been found in nets lost in the Greenland halibut fishery on the Norwegian continental slope, these nets have been found to fish still after 8 years in sea, with a catching efficiency of 20-30% of a new net (methods needs improvement). Regarding bycatch of marine mammals, the small cetaceans have been in focus, and some mitigation measures have been tested: time/area closures, acoustic pingers and gear modifications.

Longlines have weak size selectivity mechanisms, and problems with undersized catch is a problem specially in some seasonally fishing for haddock, and discards mortality is high (34-64 %). Hook-size and bait-size may help selectivity for some species. The seabird scaring line is a solution to the problem of incidental catch of seabirds.

Pots and traps have been found to be ghost fishing until 2 years after gear loss. Mortality of escapees and discards are not known.

Purse seine is basically non-selective, and discards is mostly economically motivated. Discards from net bursts when fishing Norwegian Spring spawning herring is estimated to 29-44 ' tons (total quota: 180'). Survival when sorting with grids in purse seine: 60% of mackerel, almost 100 % of saithe.

For a full report: http://www.norden.org/pub/miljo/fiskeri/sk/TN03_501.asp?lang=3

INSTITUTE OF MARINE RESEARCH

Fishing activity and ecosystem effects

Irene Huse

Fish Capture Division

Institute of Marine Research

Bergen, Norway

Content

- Rhetorical devices – operational quality
- Trawl and dredges
- Gillnets
- Longlining
- Pots and traps
- Surrounding nets

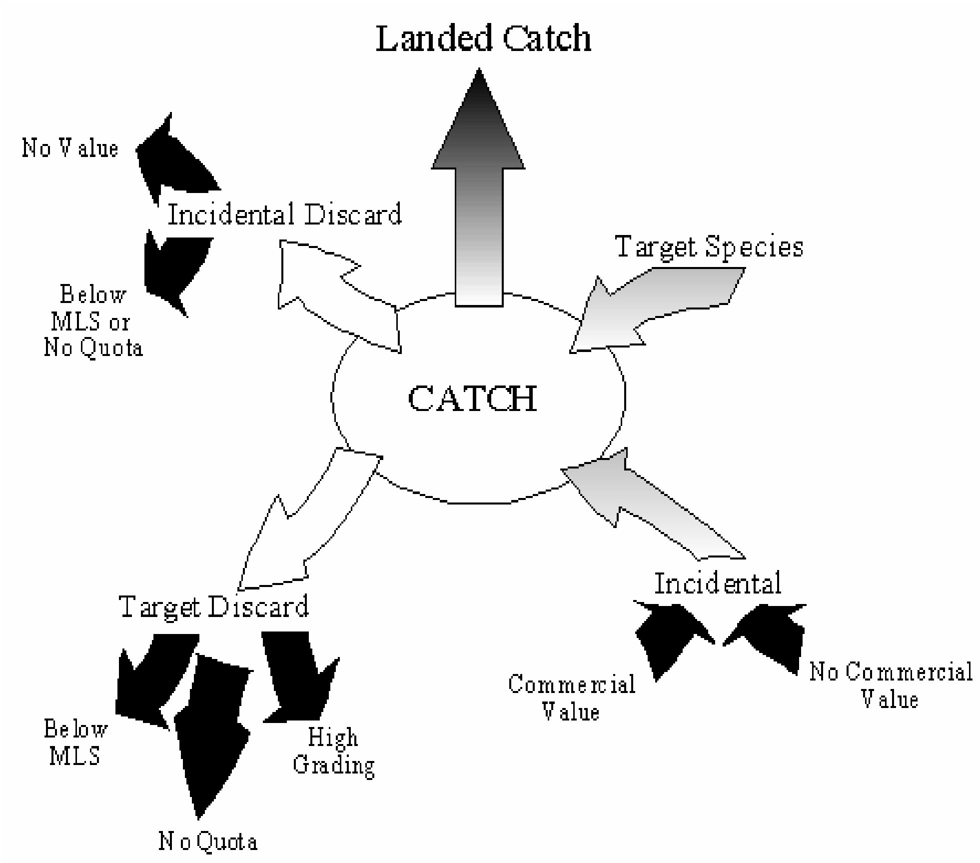
Rhetorical devices ?

- Sustainable yield
- Maintenance of biodiversity
- Protection from pollution
- Protection from habitat degradation
- For target and bycatch species: Indicators and reference points are well established: exploitation rates, SSB, distribution.

Ecological quality	Candidate properties	Candidate metrics (examples)
Biological diversity	Size structure	Slope of size spectrum Length frequency distributions Mean length of organisms sampled
	Species identity	Presence of indicator, charismatic, sensitive species
	Species diversity	k-dominance curves
	Life history composition	Distribution of maximum size
Ecological functionality	Resilience	Return time of properties of food webs
	Productivity	P/B ratio Carbon per unit area/time/volume
	Trophic structure	Distribution of production among trophic levels Connectance
	Throughput	Ratio of internal consumption to yield
	Body well being	Contaminant burden
Spatial integrity		(no candidates applicable at a community scale have been identified)

ICES 2001. Report of the Working Group on Ecosystem Effects of Fishing Activities. ICES CM 2001/ACME:09.

Unaccounted mortality in fisheries



Trawl in the North Sea

Table 2. Total discards of cod in Danish demersal fleets for 1995-2000.

Area	Gear		
North Sea	Demersal trawl	Pandalus trawl	Beam trawl
Discarded cod (weight%) of total cod catch	10	14	13
Skagerrak	Demersal trawl	Pandalus trawl	Beam trawl
Discarded cod (weight%) of total cod catch	15	61	13

Trawl in Barents Sea

- Species selectivity: separator net difficult after grid was introduced, research stopped
- Square mesh not successful
- Grid introduced for more stable size selectivity

Do escapees survive?

Escape mortality:

– Cod	0-10%
– Saithe	0-4%
– Whiting	0-50
– Haddock	15-50%
– Herring	10-100%

EU-project ”Survival”:

– Haddock	2-16%
– Whiting	0-10%

Effect of trawls and dredges

- To date it has been difficult to attribute benthic habitat changes to fishing effort (Kaiser et al. 2000).
- Few impacts of fishing have been well-documented (Currie & Parry 1996).
- Research regarding the effects of trawling on seafloor habitat has been limited to a few regions (Freese et al. 1999).
- A rapidly growing literature shows that trawling may substantially alter benthic habitats (Koslow et al 2001).
- The main bioturbator of benthic habitats is man due to his trawling (Rumohr & Krost 1991).
- Trawling disrupt the structure of benthic habitats from high latitudes to the tropics in ever-deeper waters (Watling & Norse 1998).

Physical effects

- Towed gears have different catching principles
- Otter trawls:
    - ❖Clear marks/furrows caused by the doors
    - ❖From 5 cm deep and may reach 20 cm
    - ❖Disappear within 5 months (strong current)
    - ❖Visible after 18 months (sheltered area)
- Beam trawls/scallop dredges:
    - ❖Flattening of irregular bottom topography
    - ❖Elimination of bioturbation mounds and faunal tubes.
    - ❖Penetration depth: a few to 8 cm

Biological impacts - Otter trawling
Sandy bottoms/High seas

- Experiments have been conducted in the Barents Sea, Bering Sea and on Grand Banks
- Declines in some individual taxa
- No evidences of large changes in benthic assemblages
- Considerable natural variability
- These habitats may be resistant to trawling due to high degree of natural disturbance

Biological impacts - Otter trawling
Soft bottom

- Several studies on shrimp and nephrops trawling
- Some small changes demonstrated
- But no clear and consistent effects attributed to trawling
- Natural seasonal and spatial variability
- Potential disturbance effects may be masked by more pronounced natural variability

Biological impacts - Otter trawling
Hard bottom

- Relative few (3-4) studies
- Clear effects on tall sessile invertebrates
- Large proportions (15-67%) of animals damaged by the ground gear

Habitats dominated by large sessile fauna may be severely affected

Biological impacts

Beam trawling and Scallop dredging

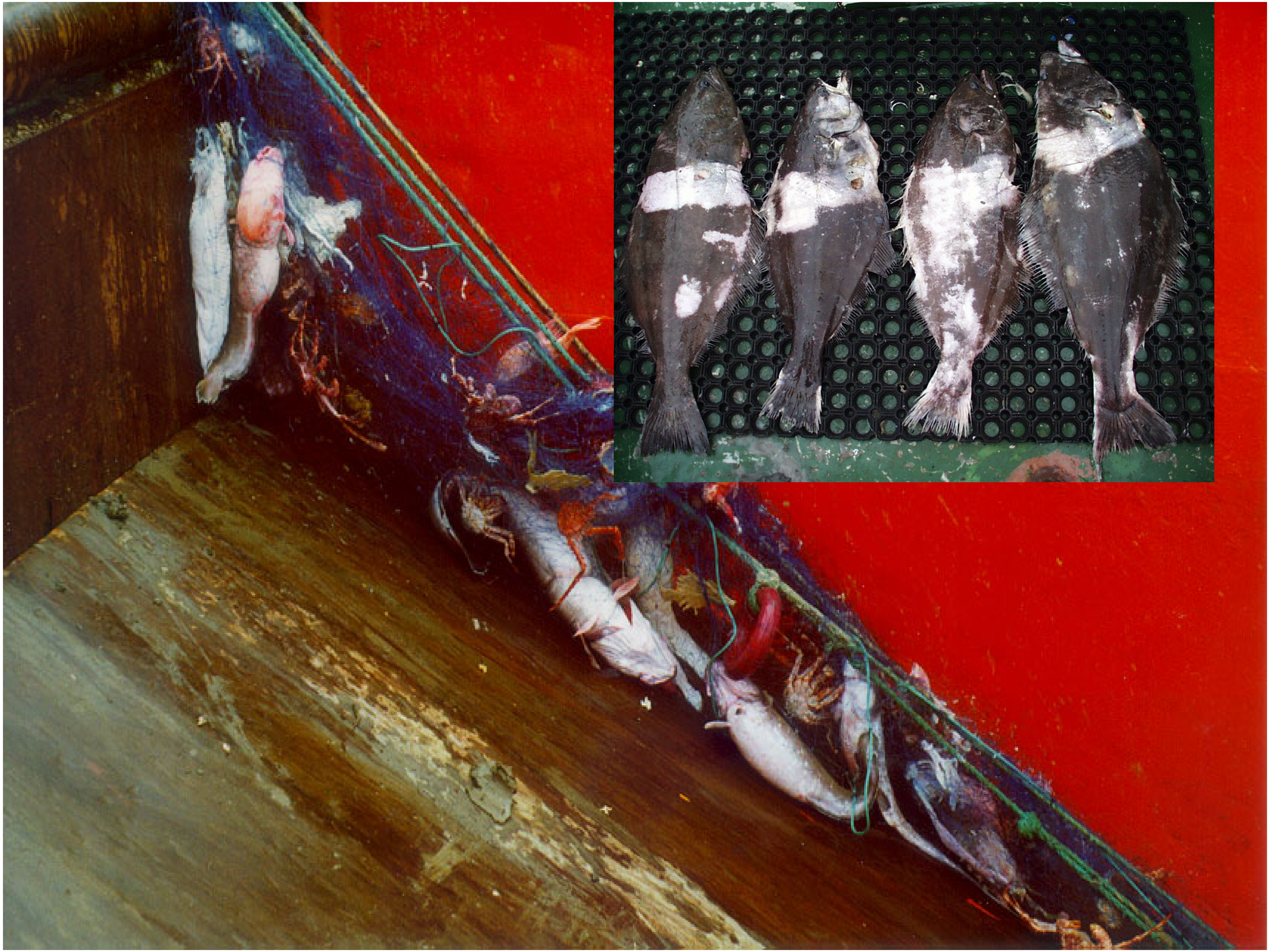
- Several studies in the North Sea, Irish Sea and other areas
- Clear evidences of short-term effects
- Decrease in number of species
- 20-80% decrease in abundance of some species
- Increase in some polychaete species
- No effects in areas subjected to natural disturbances
- Long-term effects?

Impacts of gillnets

- Ghost fishing
- Incidental catch of marine mammals

Ghost fishing

- Gillnets are lost due to gear conflicts, strong current, rupture of buoy line etc.
- These nets continue to catch fish
- The impact is more pronounced in deep waters (e.g. less fouling, difficult to find)
- High catches in the Greenland halibut fishery on the Norwegian continental slope (500-800m)



- Annual retrieval cruises in Norwegian waters since 1983
- 8309 nets retrieved (1983-2001)
- Nets may continue to fish for up to at least 8 years
- The amount of fresh fish can be used to calculate catch rates, however methods need improvement
- Indicates that lost nets have an catching efficiency of 20-30%
- Results from the FANTARED project are in press.

Marine mammal bycatch

- Focus has been on small cetaceans (e.g. harbour porpoise)
- Mortality estimates are reported
- Mitigation measures have been tested
  - Time/area closures (not successful)
  - Acoustic pingers (extra cost, labour, malfunction)
  - Gear modifications (preliminary tests are promising)

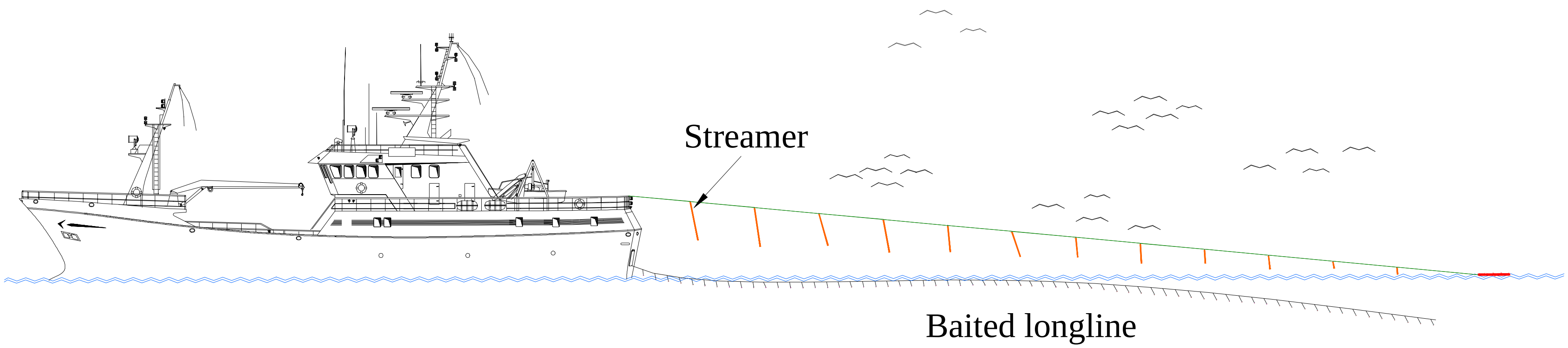
Longline

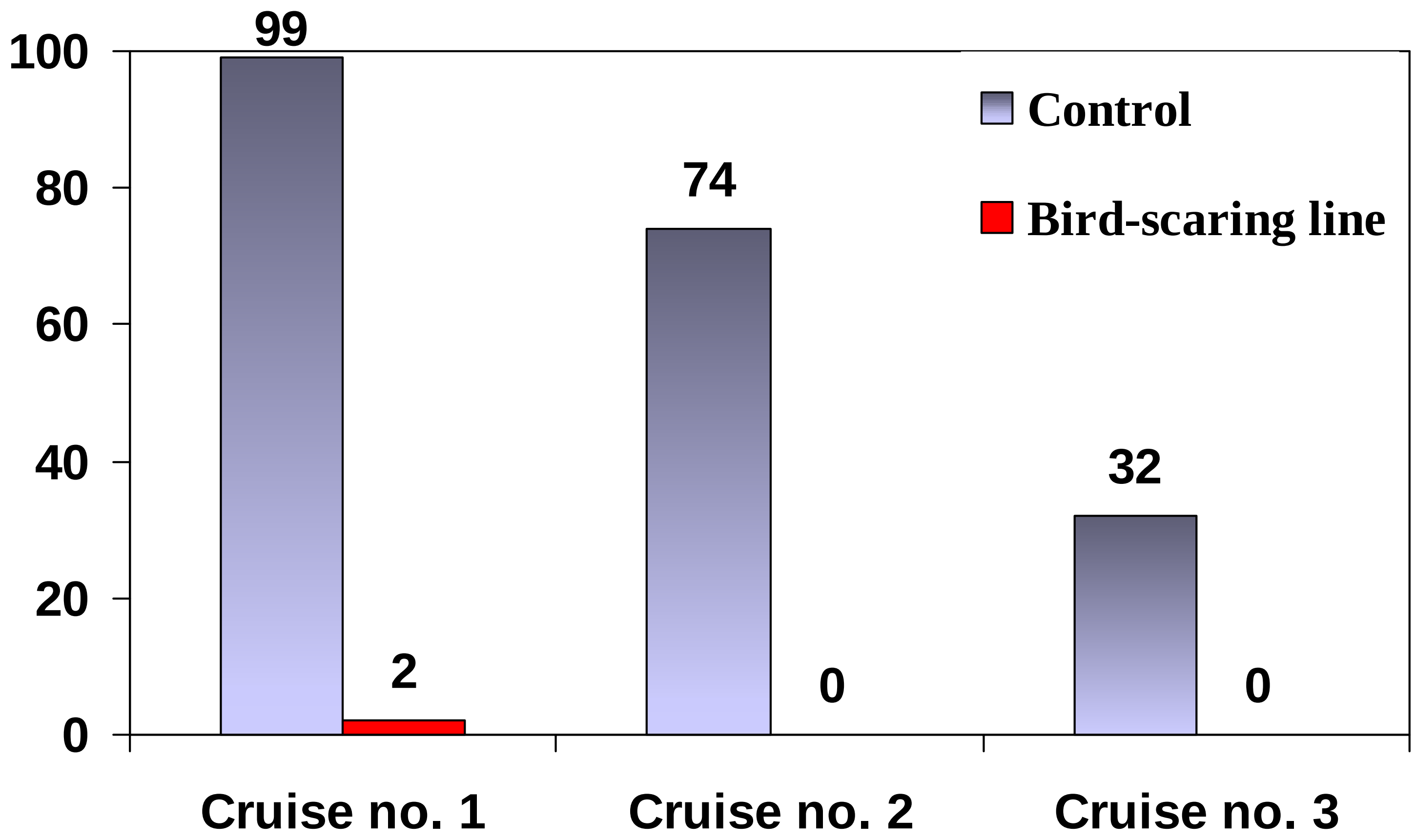
- Problem with undersized catch / discard in some seasonal fishing for haddock
- Hook-size or bait-size can improve size selection for some species
- Discard mortality probably high (34 % and 64 % dependent on method)
- Bait type most important for species selectivity

Incidental catch of seabirds

- Seabird/longline interactions lead to:
  - Bird mortality and decline in some populations
  - Bait loss and reduced gear efficiency

The Bird-Scaring Line



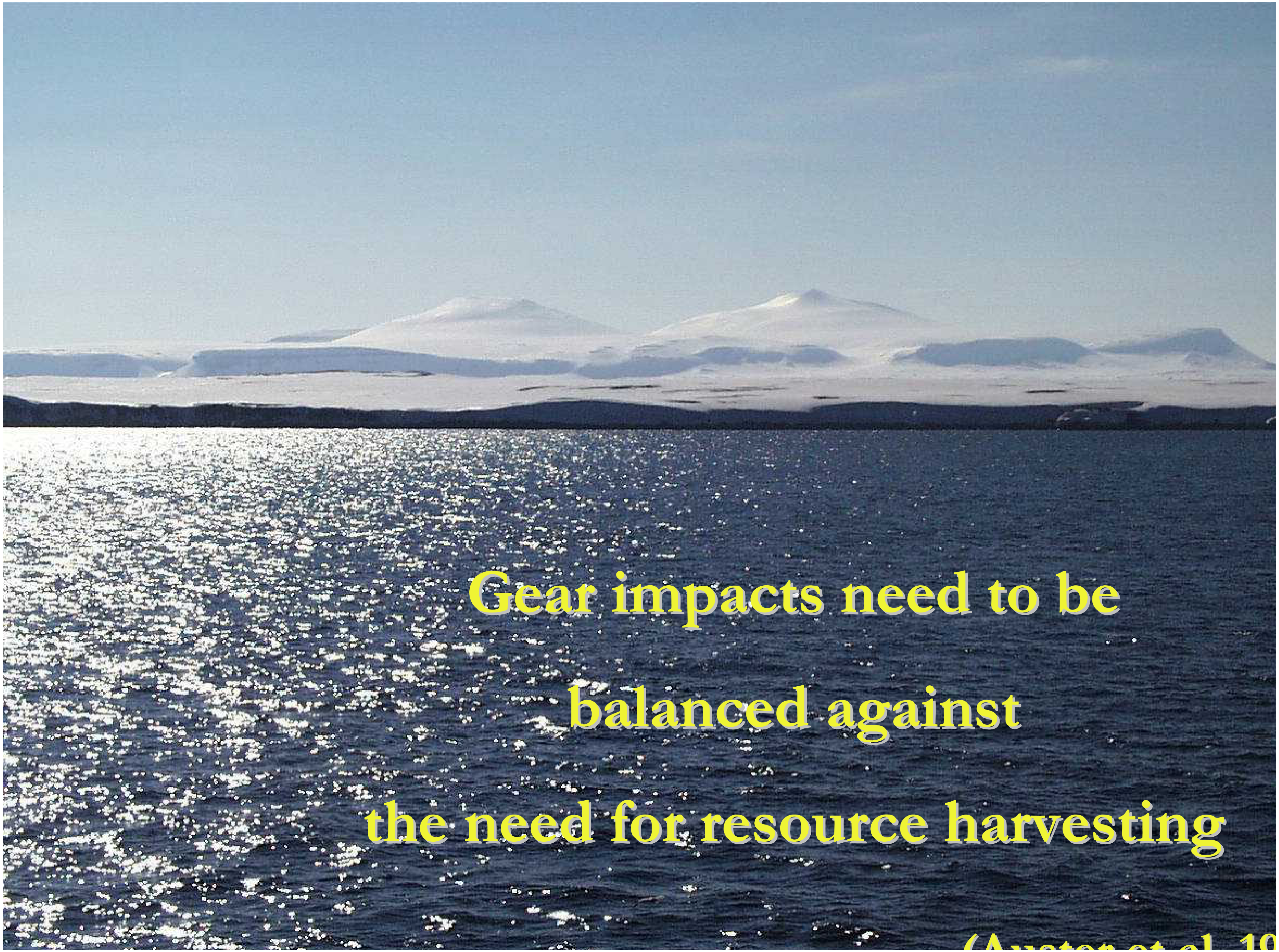

100
80
60
40
20
0
99
2
74
0
32
0
Control
Bird-scaring line
Cruise no. 1
Cruise no. 2
Cruise no. 3

Pots and traps

- Bait is most important for species selectivity
- Ghost fishing until 2 years after gear loss has been found in crab pots
- Mortality of escapees and discards are not known

Surrounding nets

- Purse seine is basically a non-selective gear
- Discards: small fish, economically motivated
- Net burst NSH: 29-44’ tons (180’ ton quota)
- Survival mortality:
  - mackerel: 60 % (grid)
  - saithe: insignificant mortality


Gear impacts need to be
balanced against
the need for resource harvesting

5.6 Combining LCA with traceability or The integration of systems such as LCA, Traceability, HACCP etc in the overall Management system

Erling Larsen

Chief Consultant

Danish Institute for Fisheries Research

The food sector and thereby also the fish processing sector is becoming more and more international. At the same time harmonisation between especially the member states of the European Union both in trade and production, has changed the conditions for the individual operation. Common legislation on e.g. hygiene and control procedures has sharpened the demands to the individual operator in combination with the fear of food scandals such as BSE and Foot and Mouth disease. This has lead to the introduction of an "Own check system", which now has been in operation for some years. This system that is taking its offspring in the HACCP system has procedures that can be used in case of recalls of products. The LCA method is dealing with the environmental impact of a process of producing a certain product.

LCA and traceability is both two systems that shall be integrated with the documentation/management systems in a sector. LCA is in nature dealing with long term influence, while traceability is an ongoing system that can be used in control situations or more specific in recalls. But on the other hand both systems is a kind of insurance and thereby they share some common features. It is the same stakeholders that are interested in having these systems e.g. the authorities, the politicians, the NGO's and the consumers. In making a LCA evaluation and to have an operational traceability system it is necessary to know where your product is coming from and to know all the ingredients. Your are making a flow diagram in both instances, the difference is that the LCA flow diagram includes the construction of buildings etc. where traceability has measurements of e.g. quality parameters.

A new field in the management system could be a construction of an LCA for environmental and human risk and LCA and Crisis Management. Then the interaction between traceability and LCA will be evident.

Combining LCA with traceability

or

The integration of systems such as LCA, Traceability, HACCP etc in the overall Management system

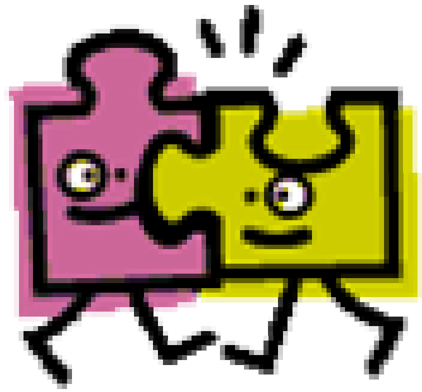
Erling Larsen

Chief Consultant

Danish Institute for Fisheries Research

Content of presentation

- What is characteristic for the different systems
  - Who is interested in the results
  - Who have the benefits
- Similarities and differences
- Cases to learn from
- Ongoing projects
- Planned projects



The scenario

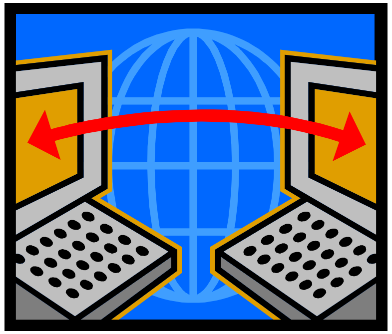
- The food sector
  - Production and quality of food
  - Methods of production, resources used
  - Impact on the surrounding environment
- Fear
  - Fear of “green-house” effect
  - Fear of food poisoning
  - Fear of being cheated
- Management
  - IT revolution
  - The global market place
- The political Interest
- The scientific interest

LCA

- Life Cycle Assessment (LCA) is a method for assessment of the environmental impact of a product through its entire life cycle
- Life Cycle Assessment (LCA) : compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:1997)

Traceability

- Traceability: ability to trace the history, application or location of that which is under consideration
  - Note 1 When considering product, traceability can relate to – the origin of materials and parts, - the processing history, and – the distribution and location of the product after delivery.



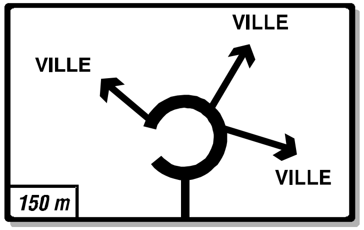
Who is interested in the results

- LCA is contributing to the long term planning – both product wise and politically
- Traceability is to prevent food scares, but are of nature belonging to the long term part of the management system – it has to be build in the product
- The stakeholders are.
- Authorities
- Politicians
- NGO’s
- Ordinary consumers+/-

Similarities LCA and Traceability

- You have to make an investigation
- You have to keep track of the materials and ingredients
- You have to audit your system regularly – validation
- When asked, you have to come up with an answer (if it is mandatory to have the system)
- Both systems are part of the management system

Differences between LCA and Traceability



- LCA includes all the production facilities, such as buildings, heating, transportation,
- An LCA is done by the link that are producing the final product – normally
- In traceability every link is responsible
- Accordingly to the new legislation, you are responsible for one link up and one down.

Validated traceability system abilities

An effective system in practice:

- **Fast reacting (recalls)**
- **Precise (brand protecting, as an insurance)**
- **Systematic traceability activities defined (procedures)**
- **Cost effective (also for SME´s to use)**

Gives access to systematic validation/audit of:

- **systems**
- **data**
- **products.**

Validation methods:

Product validation/audit: Validation of the stated product intrinsic factors (species, origin, quality etc.) by sensory or technical methods

System validation/audit:

Systematic examination of the traceability activities and related results to determine whether these comply with planned arrangements, if they are implemented effectively and suitable to achieve objectives

(Modified from ISO 10011-1:1994, Point 3.1)

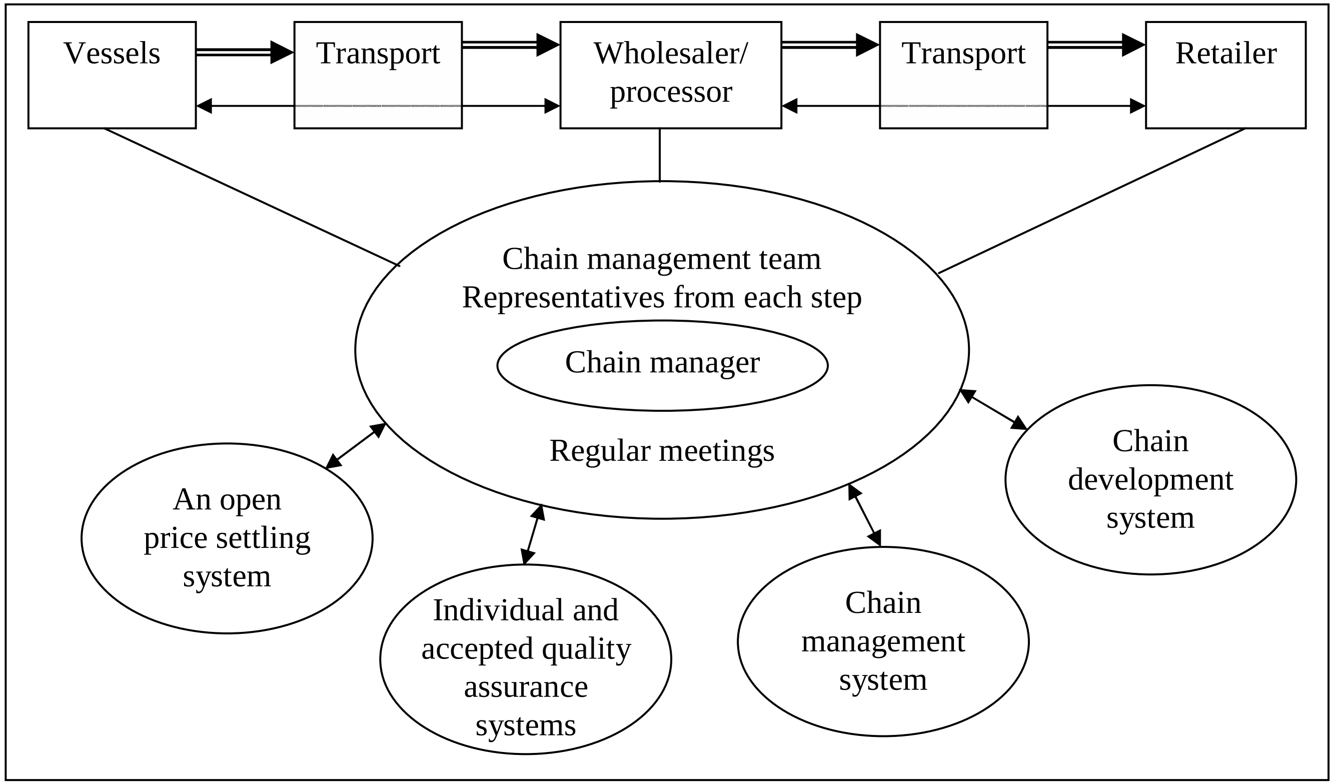
The next years to come

- Traceability can be dealt with, using paper and pen – but it will be difficult
- Data catching systems will have to implemented from the fisherman to the retailer.
- Integration of traceability with the other documentation systems in the chain will be a natural development.

The next years to come

- Traceability can be dealt with, using paper and pen – but it will be difficult
- Data catching systems will have to implemented from the fisherman to the retailer.
- Integration of traceability with the other documentation systems in the chain will be a natural development.

Model for chain cooperation



This picture shows cows on a green pasture in Ireland:

If the propose was LCA you would calculate the emission from the cows and it don't matter if it is an Irish cow or not, the fertiliser used, the milking operations etc.

If it was traceability you will concentrate on the two yellow earmarks that's tells you the unique number of the cow. Then you will check if the normal records of the cow is kept up to date.

Risk-Based Life-Cycle Assessment

- The risk for public health and environment should include close interrelation to the material and energy streams and cost throughout the lifetime.
- Then all the problems clamed on the occasions of risk-related events, i.e. traceability, accountability etc., can be discussed in the same framework of LCA

LCA can form the basis of possible options for special requirements

- The materials and energy streams gives direct and indirect impacts on the cost of the products as well as the environmental and human risks.
- This can change the optimal or possible options

LCA for environmental and human risks

- The risk should be quantified
- How to determine the threshold of the risk
- Threshold variate due to culture, political system, geographical area etc.
- Social and environmental tolerance

LCA and Crisis Management

- If you are introducing Risk-based LCA crisis management becomes an important part in this tool. The two follows each other and especially crisis management in the food industry will benefit from this achievement.

A closing remark, both paper and IT solutions should work together

Thank you for your attention